VOLUME 28 NUMBER 5

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NEXT MONTHLY MEETING, JANUARY 8, 1907

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

JANUARY, 1907

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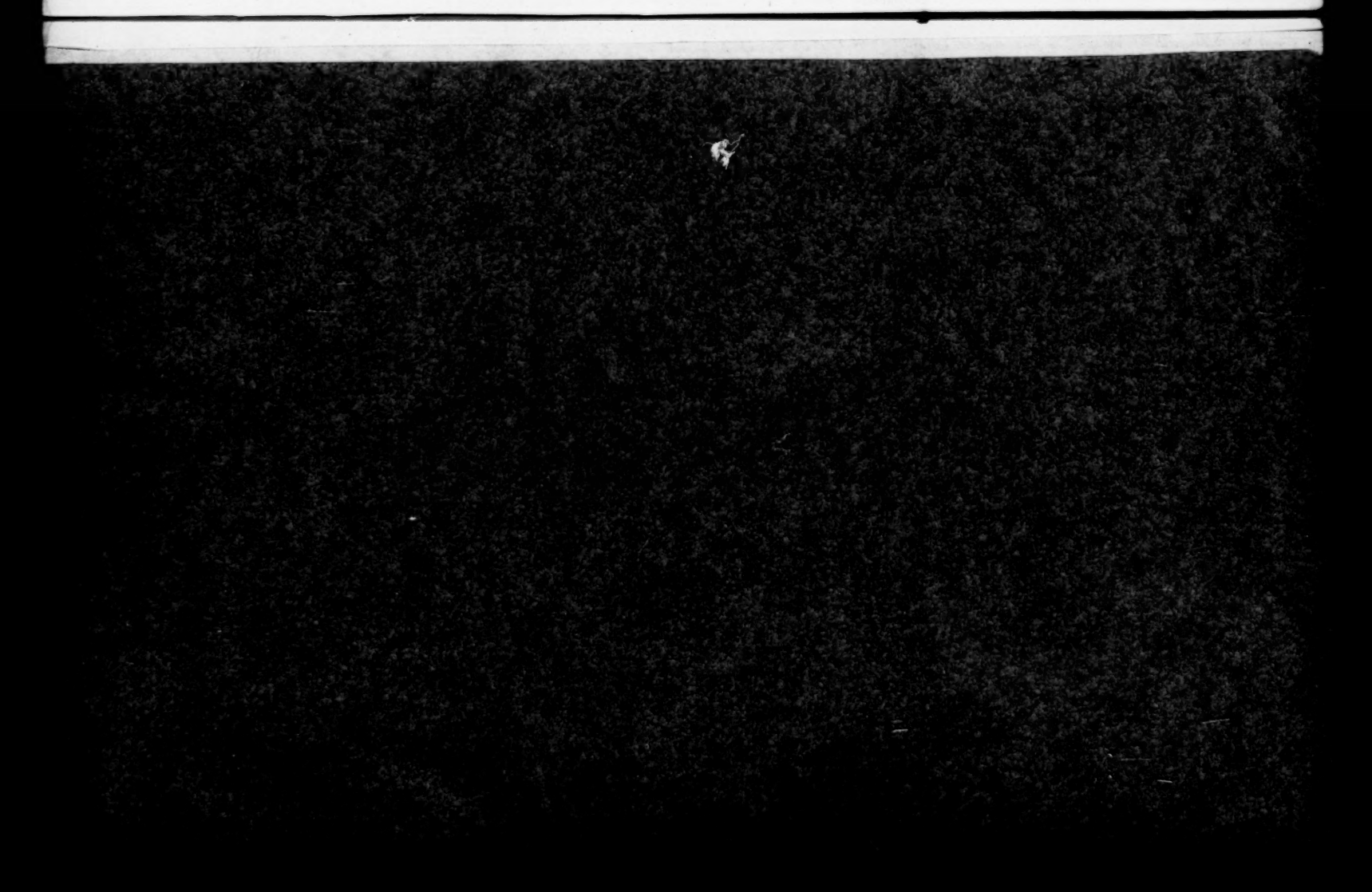
YEAR BOOK

INDIANAPOLIS MEETING, MAY 28-31, 1907



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JANUARY, 1907 VOL. 28. No. 5

THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS

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PROCEEDINGS

CONTAINING PAPERS
TO BE PRESENTED AT MONTHLY MEETINGS
OF THE SOCIETY

PUBLISHED MONTHLY EXCEPT JULY AND AUGUST
SEMI-MONTHLY IN OCTOBER AND NOVEMBER
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PROCEEDINGS
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 28 JANUARY, 1907 NUMBER 5

THE 28th Spring Meeting wil be held in Indianapolis, May 28 to 31, inclusive. Cordial invitations to the Society have been received from the local members and the civic and industrial bodies of the city.

The location is a particularly happy one, as Indianapolis is a large railroad center and can be conveniently reached from every section, and an especially large attendance is therefore expected.

Several large industrial establishments of interest are located there, and as a center of the automobile industry it is the third largest in the United States. As a consequence, it has been suggested that considerable attention be given to the mechanical engineering of the automobile, and the Meetings Committee would therefore be very pleased to receive offers of technical papers on this subject. The paper at the New York Meeting by Professor Carpenter, p. 255 of the Proceedings, is a type of professional paper which is desired, and its contribution is very valuable to the present knowledge, not only to the economies of the automobile, but to steam engineering, considering the plant in an automobile as an engine.

Other equally interesting papers and events are in contemplation.

The local committee is already at work and the chairman is Mr. J. R. Whittemore, General Superintendent of the Atlas Engine Works. We are also pleased to announce the chairman of the Ladies' Entertainment Committee, Mr. W. E. Sharp, and we are just in receipt of a letter stating that while the members are engaged at the professional sessions the ladies attending the convention will be assured of entertainment.

Notice is given that no papers for this meeting can be received after April 15. The Constitution requires that papers to be presented at meetings must be sent to the membership 30 days in advance of

that meeting. It will be impossible to prepare, print, and mail, under this Constitutional requirement, papers received after the above date. It is strongly urged, however, that members use the February, March, and April numbers of Proceedings for the publication of their papers.

Our experience at the recent convention shows that for those papers which appeared in October Proceedings we were enabled to have practically all the discussion in type prior to the meeting, and those papers which were published first received the largest amount of discussion.

Forms for February Proceedings will close January 15. Matter intended for that number should therefore reach us before that time.

JANUARY MEETING

The next meeting, which is the first regular monthly meeting of the Society, will be held on the evening of January 8. If the Engineering Building is sufficiently complete by that time the meeting will be held in the main auditorium.

The address of the evening will be given by Frederick P. Fish, Esq., of Boston, President of the American Telephone and Telegraph Company. Mr. Fish is one of the most eminent attorneys of America, and has made a specialty of patent causes. He will give an address on the subject of almost universal interest, namely, the "Ethics of Trade Secrets in Relation to the Patent System."

CONVENTION ECHOES

The program for the Annual Meeting announced in the December and the preceding numbers of Proceedings, was carried out with the exception that an inspection trip to the Sandy Hook Proving Ground and Fort Hancock was substituted for the professional session Friday, December 7. The professional session, which had been scheduled for Friday was, by vote of the Convention, moved forward to Wednesday night.

The members of the Society were the guests of the War Department. The Honorable, the Secretary of War, William H. Taft, designated as his personal representatives to receive the Society at Sandy Hook, Brigadier General William Crozier, Chief of Ordnance, and Brigadier General Arthur Murray, Chief of Artillery. Both officers took the opportunity to explain to the visitors that part of the work under inspection about which they were specially qualified to speak.

About 800 members of the Society and their guests made the trip, and witnessed perhaps the most unique demonstration of the power of the national coast defenses that it has ever been the privilege of any group of Americans to witness. Every variety of gun, from 10 inch down, were fired; mines were exploded, and ample opportunity afforded for the closest inspection of the inner workings of Fort Hancock with its mining casemates, sunken batteries, etc. The trip was made by train, and lunch was served on the cars both going and coming. It was undoubtedly one of the most enjoyable as well as instructive excursions ever made by the Society, and everyone who took part understands in what large measure we are under obligation to the War Department for this special courtesy shown the Society.

A feature of the New York Meeting was the provision to the visiting members of cards of admission to the automobile exhibition in the Grand Central Palace.

The method employed was to invite members to register their names and addresses and, through the courtesy of one of the members of the Society, the tickets were mailed direct to those registering for them.

If any did not receive cards it was due to either incorrect or incomplete address, as all requests were carefully honored.

RECEPTION

The reception at Sherry's on Thursday evening was the largest and most successful in the history of the Society. The decorations of the room and the arrangements as a whole had been carefully thought out.

Those in the receiving line were President and Mrs. F. W. Taylor; President-elect and Mrs. F. R. Hutton; the Treasurer, Major William H. Wiley; and Secretary and Mrs. Calvin W. Rice.

COMMITTEE ON STANDARD PROPORTIONS OF MACHINE SCREWS

The Chairman of the Committee on Standard Proportions of Machine Screws stated that it would be necessary to defer the final presentation of the report until the Spring Meeting. The following reason was given by the Committee.

"Within the last two weeks, the Committee on Standard Proportions of Machine Screws has received a request from a number of the largest manufacturers of machine screws for a modification of some of the tables in the Committee's report which was printed in the October Proceedings. At a meeting held December 4, the Committee

decided to take the matter into consideration, and therefore will not ask for the adoption of their report at this meeting.

The members of the Committee wish to say that the tables in question were adopted by them in good faith, after full consultation with and approval by the manufacturers, also in good faith. With earnest effort and the hearty aid which is promised by the manufacturers, we hope to present a satisfactory report to the next meeting.

"Through many conflicts, toils and cares
We have already come."

The Society will move into its new quarters in the Engineering Building about January 1. All communications after that date should be addressed to 29 West 39th Street.

DISCUSSION CONTRIBUTED AT THE MEETING

REPORT MACHINE SCREW COMMITTEE

Written

D. A. Wallace
The Secretary

ART OF CUTTING METALS

By Mr. F. W. Taylor

Written	*Oral*
Henry R. Towne	Oberlin Smith
H. L. Gantt	W. S. Huson
D. Adamson	J. M. Dodge
C. W. Rice	
Vickers Sons & Maxim, Sheffield, Eng.	
John T. Hawkins	
Dr. J. T. Nicholson	
Fred M. Osborne, Sheffield, Eng.	
Mr. Codron. Paris, France	
H. Le Chatelier	
Prof. L. P. Breckenridge	
H. C. H. Carpenter, Manchester, Eng.	
Mr. H. K. Hathaway	
J. Bancroft Sellers	

EVOLUTION OF GAS POWER

By Mr. F. E. Junge
Member Verein Deutscher Ingenieure

Written	*Oral*
Prof. R. C. Carpenter	Prof. C. E. Lucke
R. E. Hellmund	R. E. Mathot
W. D. Ennis	
H. Diederichs	
J. E. Johnson, Jr.	
Geo. J. Rathbun	
A. J. Wood	
C. G. Atwater	
R. H. Fernald	

PRODUCER GAS POWER PLANT

By Mr. J. R. Bibbins

Written

W. D. Ennis

STEAM TURBINE CHARACTERISTICS

By Mr. Hans Holzworth

Written

Capt. H. Riall Sansky, R. E.

THE STEAM PLANT OF THE WHITE MOTOR CAR

By Prof. R. C. Carpenter

Written	*Oral*
Prof. R. C. Carpenter, Appendix	W. E. Johnson
Prof. C. C. Thomas	

DESIGN OF AN IMPROVED BOILER SETTING

By Mr. A. Bement

Written	*Oral*
Prof. L. P. Breckenridge	Prof. D. S. Jacobus
W. D. Ennis	
Prof. Wm. Kent	
W. L. Abbott	
Albert A. Cary	
E. A. Hitchcock	
Embury McLean	
Jay M. Whitham	
Wm. H. Bryan	
J. C. Barker	

VENTILATION BOSTON SUBWAY

By Mr. H. A. Carson

Written	*Oral*
C. S. Churchill	Theo. Weinshank
Prof. S. H. Woodbridge	
W. Clifford	
Francis Fox	
W. R. Snow	

TEST OF A ROTARY PUMP

By Prof. W. B. Gregory

Written

Prof. R. C. Carpenter
A. M. Lockett

PLAN TO PROVIDE SKILLED WORKMEN

By M. W. Alexander

Written

M. P. Higgins
John Knickerbacker
Prof. R. C. Richards
Fred W. Taylor
Prof. Williston

Oral

Prof. E. Robinson
W. S. Huron
L. D. Burlingame
H. F. J. Porter
G. R. Henderson
C. F. MacGill
Prof. G. Lanza
P. W. Gates

HIGH DUTY AIR COMPRESSOR

By Prof. O. P. Hood

Written

Geo. H. Barrus
Prof. R. C. Carpenter
Prof. Storm Bull
W. Y. Lewis
S. A. Moss
W. L. Saunders

Oral

F. V. Henshaw

TESTS OF AN ELEVATOR PLANT

By Mr. A. J Herschmann

Written

Thomas E. Brown
W. Y. Lewis, Jr.
Fredk. Meriam Wheeler
E. S. Matthews
W. H. Bryan

IMPROVED TRANSMISSION DYNOMOMETER

By Mr. W. F. Durand

Written

Prof. R. C. Carpenter
Prof. J. J. Flather

FLOW OF FLUIDS IN A VENTURI TUBE

By Mr. E. P. Coleman

Written

Prof. R. C. Carpenter
S. A. Moss
Clemens Herschell

Oral

Prof. Williston

SAW-TOOTH SKYLIGHT IN FACTORY ROOF CONSTRUCTION

By Mr. F. S. Hinds

Written

S. M. Green
L. H. Kunhardt
Prof. J. E. Sweet
G. R. Henderson
Walter B. Snow

Oral

W. B. Snow
K. C. Richmond

FERROINCLAVE ROOF CONSTRUCTION

By Mr. A. E. Brown

Written

E. N. Hunting

Oral

Theo. Weinshank
B. N. Bump

SAW-TOOTH ROOF FOR FACTORIES

By Mr. K. C. Richmond

Written

S. M. Green
L. H. Kunhardt
H. V. Haight
Fred S. Hinds
J. R. Fordyce

WEIGHTS AND MEASURES

By Mr. Henry R. Towne

Written

H. H. Suplee
F. A. Halsey
G. W. Melville
Wm. Kent
Jas. M. Christie
Geo. Schuhman
J. Sellers Bancroft
S. S. Dale
S. Webber
Oberlin Smith
J. C. Parker

Oral

O. Smith
Prof. Jacobus
L. D. Burlingame
Mr. Miller
E. N. Trump
J. M. Smith
F. H. Boyer

MECHANICAL ENGINEERING INDEX

By Professors Bird and Smith

Written

Prof. L. P. Breckenridge
Wm. Kent
Henry Hess
L. D. Burlingame

The attendance at the convention was the largest in the history of the Society, reaching 1352. This is particularly gratifying, especially in view of the fact that of the total attendance the larger part was made up of members of the Society. Among the members present were:

Frederick B. Abbott, Emporia, Kan.
J. H. Abercrombie, Newark, N. J.
E. T. Adams, Milwaukee, Wis.
Louis R. Alberger, New York, N. Y.
Geo. L. Alden, Worcester, Mass.
H. L. Aldrich, New York, N. Y.
Jno. G. Aldrich, Providence, R. I.
L. A. Alexander, Ansonia, Conn.
Magnus H. Alexander, Lynn, Mass.

Percy Allan
Montclair, N. J.
Wm. T. Allan
Jersey City, N. J.
Chas. M. Allen
Worcester, Mass.
Henry A. Allen
Chicago, Ill.
Walter C. Allen
Stamford, Conn.
W. M. Allen
Cleveland, Ohio.
Robt. Allison
Port Carbon, Pa.
Darwin Almy
Providence, R. I.
Julius Alsberg
New York, N. Y.
C. H. Alvord
Torrington, Conn.
H. W. Appleton
Passaic, N. J.
Albert C. Ashton
Somerville, Mass.
Harold B. Atkins
Roselle, N. J.
C. G. Atwater
New York, N. Y.
Geo. D. Atwood
Jamaica, N. Y.
Jerome J. Aull
Cincinnati, O.
W. S. Austin
Brooklyn, N. Y.
F. L. Antisell
Perth Amboy, N. J.
E. A. Averill
New York, N. Y.
D. G. Baker
Ilion, N. Y.
Geo. O. Baker
New York, N. Y.
J. C. W. Baker
Naugatuck, Conn.
Wm. J. Baldwin
Brooklyn, N. Y.
Chas. W. Barnaby
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Jno. M. Barnay
New York, N. Y.
W. F. Barnes
Rockford, Ill.
Percy C. Barney
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Jno. H. Barr
Syracuse, N. Y.
Geo. H. Barrus
Boston, Mass.
F. F. Baestow
Mittineague, Mass.
Carl G. Barth,
Philadelphia, Pa.
Henry L. Barton
Pittsburg, Pa.
A. F. Batchelder
Schenectady, N. Y.
Albert H. Bates
Cleveland, O.
Alex. B. Bates
Binghamton, N. Y.
E. P. Bates
Syracuse, N. Y.
Chas. L. Bauer
Springfield, O.
A. R. Baylis
Flatbush, N. Y.
R. N. Baylis
Englewood, N. J.
Frank F. Beall
Providence, R. I.
E. A. Beaman
Providence, R. I.
Chas. H. Benjamin
Cleveland, O.
T. A. Bennett
New Brighton, N. Y.
C. P. Benns
New York, N. Y.
J. R. Bibbins
Pittsburg, Pa.
M. J. Bigelow
Stamford, Conn.
C. E. Billings
Hartford, Conn.
Wm. R. Billins
New York, N. Y.
Wm. W. Bird
Worcester, Mass.
John Birkinbine
Philadelphia, Pa.
Chas. A. Blatchley
Washington, D. C.
Wm. H. Blauvelt
Syracuse, N. Y.
Wm. H. Baehm,
New York, N. Y.
Emile C. Boerner
Portchester, N. Y.
Wm. A. Bole
Pittsburg, Pa.
Reginald Pelham Bolton
New York, N. Y.
Geo. M. Bond
Hartford, Conn.
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New Britain, Conn.
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Austin Lord Bowman
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E. S. Boyer
New York, N. Y.
Francis H. Boyer
Somerville, Mass.
W. G. Bradley
Troy, N. Y.
W. H. Bradley
New York, N. Y.
Josephine T. Bragg
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S. N. Braman
Philadelphia, Pa.
Jos. Breslove
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New Britain, Conn.
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Passaic, N. J.
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G. A. Gulowsen
Hugenot Park, N .Y.
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DONATIONS[1]

RAILWAY ORGANIZATION AND WORKING. A Series of Lectures Delivered before the Railway Classes of the University of Chicago. Edited by Ernest Ritson Dewsnup. *The University of Chicago Press, Chicago, 1906.* Price, $2.

Contents: The Work of the Law Department of a Railroad Company, by Blewett Lee. The Passenger Department, by Percy S. Eustis. Railroad Advertising, by Chas. S. Young. Suburban Passenger Service, by William L. Smith. The Industrial Commissioner, by Wm. H. Manss. The Problem of Handling Less than Carload Freight Expeditiously and Economically at Terminal Stations, by Nelson W. Pierce. Office Work in Terminal Yards, by Ferdinand S. Atkin. Car Distribution and the Supervision of Fast Freight, by John M. Daly. The Problem of Car Service, by Walter E. Beecham. Freight Claims, by Ralph C. Richards. Some Notes on Freight Rates, by Ernest R. Dewsnup. Organization of the Operating Department of Railroads, by R. H. Aishton. The Purchasing Agent, by E. V. Dexter. Ballast, by A. S. Baldwin. Railway Terminal Facilities, by L. C. Fritch. Railroad Signaling, by Chas. A. Dunham. Classification and Types of Locomotives, by C. A. Seley. The Compound Locomotive, by W. R. McKeen, Jr. Car Construction, by J. H. Ames. Duties of a Comptroller or Chief Accounting Officer, by F. Nay. The Auditor of Expenditures, by Harry M. Sloan. The Work of the Freight Auditor, by W. F. Dudley. Vitalized Statistics, by James Peabody. Railway Development in Canada, by Wm. McNab. Railway Education, by Ernest R. Dewsnup. Appendix.

LOCOMOTIVE DICTIONARY. Compiled for The American Railway Master Mechanics' Association. By George L. Fowler, Associate Member, American Railway Master Mechanics' Association. Under the Supervision of the following Committee: J. F. Deems, General Superintendent Motive Power, New York Central Lines; A. W. Gibbs, General Superintendent of Motive Power, Pennsylvania Railroad; A. E. Mitchell, late Superintendent Motive Power, Lehigh Valley Railroad. *The Railroad Gazette, New York, Chicago; The Railway Gazette, London, 1906.* Price, $6.

An Illustrated Vocabulary of Terms which Designate American Railroad Locomotives, their Parts, Attachments, and Details of Construction, with Definitions and Illustrations of Typical British Locomotive Practice. Five Thousand one Hundred and Forty-eight Illustrations. First Edition.

THE CAR BUILDERS' DICTIONARY; Compiled for the Master Car Builders' Association, by Rodney Hitt, Associate Member, Master Car Builders' Association. *The Railroad Gazette, New York, Chicago; The Railway Gazette, London, 1906.* Price, $6.

An Illustrated Vocabulary of Terms which Designate American Railroad Cars, their Parts, Attachments, and Details of Construction, with Definitions and Illustrations of Typical British Practice in Car Construction. Four Thousand Three Hundred and Forty-four Illustrations. 1906 Edition.

[1]Books in this list have been donated by the publishers.

AMERICAN RAILWAY SHOP SYSTEMS. By Walter G. Berg. *The Railroad Gazette, New York, 1904.* Price, $2.

Contents, according to chapter headings: Classification and General Layout; General Repair Shops; Locomotive Repair Shops; Passenger Car Repair Shops; Freight Car Repair Shops; General Shop Store Houses; Power Plant and Machinery. Structural Work of Buildings and Auxiliary Features; Bibliography; Illustrations.

BOILER—WATERS, SCALES, CORROSION, FOAMING. By William Wallace Christie, Consulting Engineer, Member American Society Mechanical Engineers. Illustrated. *D. Van Nostrand Co., New York, 1906.* Price, $3.

Contents, by chapter headings: Water, its Properties. Material Found in Water, Water Analysis; Boiler, Scale, Transmission of Heat, Conductivity of Solids; Corrosion; Feed-water Pipes, Blow-off Pipes, Tubes; Priming and Foaming; Oil, Grease, Zinc; Hardness of Water; Feed-water Heaters, Economizers; Water-softening; Miscellaneous Tables.

THE COST OF LOCOMOTIVE OPERATION. By George R. Henderson, M. E., Member American Society Mechanical Engineers; Member American Railway Master Mechanics' Association. *The Railroad Gazette, New York, Chicago; The Railway Gazette, London, 1906.* Price, $2.50.

Contents: The following subjects are treated of in its chapters—Expenses Classified; Fuel Water; Lubricants; Waste; Tools; Miscellaneous; General Repairs; Running Repairs; Renewals; Engineers; Firemen; Hostling and Turning; Cleaning Fires; Wiping; Inspection; Firing-up and Coaling; Applicants.

HANDBOOK OF PRACTICAL SMITHING AND FORGING. With Numerous Illustrations, Examples and Tables. By Thomas Moore, Foreman and Practical Smith. *E. & F. N. Spon, Ltd., London; Spon & Chamberlain, New York, 1906.* Price, $2.

Contents by chapter headings: Introductory; Forges or Hearths; Hammers, Forging Machines and Presses; Iron and Steel; Testing; General Forging and Smithing: Summary and Explanation of Technical Terms, Expressions and Phrases; Tables; Index.

INSTITUTION OF CIVIL ENGINEERS. *Transactions, Volume 164, 1906.*

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA. *General Index, Volumes 1–20, 1880–1904.*

CHEMICAL, METALLURGICAL, AND MINING SOCIETY OF SOUTH AFRICA. *Journal and Supplement, June–August, 1906.*

NATIONAL FIRE PROTECTION ASSOCIATION QUARTERLY. *Bulletin, October, 1906.*

PUMPS AND HYDRAULICS. By Wm. Roger. *New York, 1905.*

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ENGINEERING STANDARDS COMMITTEE. *Reports 24, 28, and 31, 1906.*

BUREAU OF LABOR OF CONNECTICUT. *Report for 1905.*

NATIONAL BATTERY COMPANY. *Bulletins 1-6, and Publications 28-30.*

COST OF LOCOMOTIVE OPERATION. By George R. Henderson.

INTERNAL ENERGY. By John V. V. Booraem.

THE SAN FRANCISCO EARTHQUAKE AND FIRE. By A. L. A. Himmelwright. The Roebling Construction Company.

THE SAFEGUARDING OF LIFE IN THEATRES. By John R. Freeman.

CAMS. By C. F. Smith and F. A. Halsey.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both as to positions and as to men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 20th of the month. The list of men available is made up entirely of members of the Society and these are on file, with the names of other good men, not members of the Society, capable of filling responsible positions, information about whom will be sent upon application.

POSITIONS AVAILABLE

09 Large engine building concern desires energetic, tactful young man to look after the general welfare of its apprentices. Preference to one who has had two years' successful experience as instructor in a technical school and some experience as a working mechanic. Appointment should be attractive to instructor who wishes to get into commercial engineering work, or it would furnish experience that would broaden his field of usefulness should he desire to resume the teaching profession. Location, Pennsylvania.

010 Wanted in a technical college an instructor in applied electricity; should have several years' practical experience in electrical work. Teaching experience while desirable is not necessary. Salary, $1200 to $1400. A gentleman of proper personality and high character essential. Location, State of New Jersey.

011 Wanted a young man, 25 to 30 years of age, in an executive position in textile manufacturing plant. Location, New Jersey. Salary, $1800 to $2000. To the right man a part interest would be afforded which would yield about $750 per year additional income. The man for this position must have engineering ability, resource, tact, and a personality such that he can grow up with the business and succeed to full responsibility.

012 Young mechanical and electrical engineer who has had there of four years' practical experience in engineerng and construction work. Salary, $100 to $125 a month. Location, Kentucky.

013 Superintendent for Canadian works of company desires a man thoroughly experienced in shop management, press work, shearing, and general metal working.

MEN AVAILABLE

13 Mechanical engineer, member, 37 years of age, with several years' experience in designing all sizes of gas engines up to one thousand horse power, desires arrangement with up-to-date firm for manufacturing a line of gas engines from his designs and patents.

14 Technical graduate, degree of M. E. and extra work in electrical engineering. Experience as draftsman on valve gear Curtis turbine, assistant engineer, directing work and testing steam trucks, gasolene touring cars and small two cycle oil engines.

15 Position in selling organization of manufacturing concern. Technical and practical training, also extensive commercial experience. References of high character regarding ability and successful work. Desires position of responsibility with progressive concern appreciating merit and earnest application. At present occupying position as New York sales manager of large manufacturing concern.

16 Member; successful mechanical engineer, age 42, extensive practical experience in all branches of machine shop and factory work, desires position as works manager or superintendent. Good executive ability in organizing shop force and handling men. Thoroughly understands high speed steel, time and cost systems, mechancally increasing product ion and reducing costs.

17 Mechanical engineer, junior member, technical graduate, four years' experience in design, inspection, superintendence, traveling and general office work of a technical nature, desires a position as assistant to engineer.

18 Mechanical engineer, college graduate, would take management of small manufacturing establishment on percentage basis.

19 Member with wide experience as business manager and engineer, intending to make change, would accept managership or other suitable executive position with manufacturing or contracting concern.

A COMPARISON OF UNIVERSITY AND INDUSTRIAL METHODS AND DISCIPLINE

AN ADDRESS DELIVERED BY MR. FREDERICK W. TAYLOR, PRESIDENT OF THE SOCIETY, AT THE DEDICATION OF THE NEW ENGINEERING BUILDING OF THE UNIVERSITY OF PENNSYLVANIA

The point from which I view college education is that of the employer, not that of the educator. I have had no experience with the difficult and complicated problem that faces the professors and the governing boards of our colleges. On the other hand, I have been engaged for years in organizing the shop, office, and commercial management of quite a wide range of engineering and manufacturing establishments. This has brought me into intimate personal contact with a large number of college graduates, and I have become well acquainted with their strong points, which are many, and at the same time with a few of those points in which it would seem that as a class they might be improved. And in what I shall say I have principally in mind the preparation of young men for success in commercial engineering and industrial enterprises; in other words, enterprises outside of the four learned professions.

I despise the pessimist who sees nothing but the defects and blunders of mankind; and the scold, whose pleasure it is to complain of all things as they are.

Let me say at the start, that without question, our college graduates as a class represent the finest body of men in the community. And as to the value of an engineering course for men in our profession, it has been shown through carefully gathered statistics, that within a few years after graduation the college educated engineer far outstrips in position and salary his average competitor who comes up from the ranks.

It would be a much more congenial task to dwell upon this view of the profession, but something may possibly be gained by considering what has seemed to many of the friends of our young graduates to be the one defect which they practically all have in common.

For a period of from six months to two years after graduating they are, generally speaking, discontented and unhappy. They are apt to

look upon their employers as unappreciative, unjust, and tyrannical, and it is frequently only after changing employers once or twice and finding the same lack of appreciation in all of them, that they finally start upon their real careers of usefulness.

On the other hand, the attitude of employers toward young graduates is fairly expressed by the following written instructions given for the selection of quite a large number of young men to fill positions which presented opportunities for rapid development and advancement. These instructions were to give the preference—first, to graduates of technical schools; second, to the graduates of the academic departments; but to employ no college boy who had not been out for more than two years.

Why is it, then, that these young men are discontented and of practically little use during the first year or two after graduating?

To a certain extent this is unquestionably due to the sudden and radical change from years spent as boys almost solely in absorbing and assimilating knowledge for their own benefit to their new occupation of giving out and using what they have for the benefit of others. To a degree it is the sponge objecting to the pressure of the hand which uses it. To a greater degree, however, I believe this trouble to be due to the lack of discipline and to the lack of direct, earnest, and logical purpose which accompanies, to a large extent, modern university life.

During the four years that these young men are at college they are under less discipline, and are given a greater liberty than they have ever had before or will ever have again.

As to college discipline, it cannot be a good training for after life for a young man deliberately to be told by the university authorities that he can flagrantly neglect his duties sixty times in one term before any attention will be paid to it; while, if in business, the same young man would be discharged for being absent two or three times without permission.

And, as to the freedom offered by the modern university system, it is not true that boys from eighteen to twenty years old have the knowledge and experience necessary to select a logical and well-rounded course of studies, and even if they had this wisdom, the temptation to choose those studies which come easiest is so strong that it would be unwise to throw upon them so great a responsibility. Nor does it appear wise to leave each student free to study as little or as much as may suit him, at times doing practically no work for days, and at others greatly overworking, with no restraint or direction except the round-up which comes twice a year with examinations. At the

least, it must be said that in commercial or industrial life this undirected liberty will never again be allowed them.

During the past thirty years two radical changes have occurred in educational methods. The kindergarten and its accompanying ideas has come for the children, and for the young men has come the change from the college, with its one or two courses carefully selected and rigidly prescribed by the faculty, to the university with as many different courses as there are young men, and in which, under the elective system, each student is given the choice of all of his studies.

The fundamental idea back of the change from college to university is excellent; namely, that of providing a far greater variety in the courses to suit the different tastes and abilities of the students, and to especially prepare them for their future occupations. Accompanying, however, this great step in advance, and yet, so far as I can see, in no way logically connected with it, has come the false step of giving our young men in many ways a greater liberty than is allowed, on the whole, to any other class of active workers; and of handing over to them the final decision in a subject most needing a master mind.

Commercial, manufacturing, and other enterprises in which many men coöperate, are managed more and more by delegating all important decisions to a few men whose judgment has been trained through long experience, study, and observation in those matters which they are called upon to decide. Yet many of our universities are managed by giving over to the young man, under the elective system, the final decision as to what studies will best fit him for his life's work, although he has, of necessity, but the vaguest idea of the nature of the subjects which lie before him. It is almost like asking him to lift himself up by his boot straps.

I cannot but think that in changing we have modeled largely after the English and German universities, which, as we know, are influenced in their management by traditions handed down through several hundred years; and that in adopting the great university idea of a variety of courses, we have at the same time blindly accepted the foreign idea of the elective system accompanied by a lax discipline, both of which are better suited to medieval times when each man worked for himself than to the present day when the road to success lies through true coöperation.

In this change, also, too great stress has been laid upon those elements leading to knowledge or book learning on the part of the student and too little upon the development of his character.

The kindergarten also, which has proved so great a help in training the younger children, making them observant and giving them a

certain control over themslves, has brought with it one idea which has wrought great harm, and yet this bad idea is in no way properly or logically connected with the underlying principles of the kindergarten.

Somehow the average kindergarten child gets a firm conviction that it is the duty of the teacher to make things interesting and amusing, and from this follows soon the notion that if he does not like his studies and fails to learn much, it is largely the teacher's fault. Now, whatever views the parents or the teachers themselves should hold upon the duties of teachers, there is no doubt that the boys should have firmly in their heads the good old-fashioned idea that it is their duty to learn, and not that it is the duty of the teacher to teach them.

Along with the kindergarten plan of interesting and amusing children, the idea has taken firm hold in a large portion of the educational world that the child and young man should be free to develop naturally, like a beautiful plant or flower. This may again be an excellent view for the older person to hold, but it is a distinctly bad one for the young man to act upon. He promptly translates the idea of developing naturally into wishing to do only, or mainly, those things which he likes or which come easy to him.

Of all the habits and principles which make for success in a young man, the most useful is the determination to do and to do right all those things which come his way each day, whether they are agreeable or disagreeable; and the ability to do this is best acquired through long practice in doggedly doing along with that which is agreeable a lot of things which are tiresome and monotonous, and which one does not like.

Now neither the kindgarten idea, the university elective system, nor the lax college discipline tend to develop this all important habit in young men.

True coöperation, coöperation upon the broadest scale, is that feature which distinguishes our present commercial and industrial development from that of one hundred years ago. Not the coöperation taught by too many among those of our trades unions which are misguided, and which resembles the coöperation of a train of freight cars; but rather that of a well-organized manufacturing establishment, which is typified by the coöperation of the various parts of a watch, each member of which performs and is supreme in its own function, and yet is controlled by and must work harmoniously with many other members.

It is a mistaken notion that character of this kind needed for successful coöperation is developed by the elective idea of allowing each

boy to choose for himself those things which he will do. It requires far more character to do successfully those things which are laid out for one by a wiser man than to do only what one likes, and in modern coöperation, while the work of each man is modified and more or less controlled by that of others, there is ample scope left for originality and individuality. We must remember that of all classes in the community, college boys are being trained to fill some day the position of leaders in the coöperative field. And there is no fact better established than that the man who has not learned promptly and fully to obey an order is not fit to give one.

An examination of the studies chosen by boys in the university academic departments will show that the logic and motive back of about one-half of the students is that of obtaining an easy course, and even the better students show generally a lack of clear-cut logical purpose in their selection. In their case, the studies are chosen because the young man likes or is interested in the subjects, or because they come easy to him, rather than because they give a well-rounded and balanced course with a distinct logical purpose. The loose, flabby, purposeless courses chosen by fully one half of the students under the present system furnish but poor mental diet.

Why cannot all of the good features of the elective system be better attained by permitting each young man to choose in general the object or purpose for which he wishes to educate himself, and then leave the entire course of studies to the one or more professors in the faculty who are especially fitted to plan a complete and logical course in the chosen field? Let the young man say where he wishes to go, and let the faculty tell him the road he is to travel to get there.

As to the object of college life, some boys are sent to the university to learn how to mingle with men, and to form friendships which shall prove useful and agreeable in after life. Some go there to amuse themselves, and some to get the standing given by a college degree.

Something can be said for each of these objects. Is not the true object of all education, however, that of training boys to be successful men? I mean men successful in the broadest sense, not merely successful money getters. Successful, first in developing their own characters, and second, in doing their full share of the world's work.

Young men should not come to college mainly to get book learning or a wide knowledge of facts. The successful men of our acquaintance are, generally speaking, neither learned nor men of great intellect. They are men, first of all, possessed with an earnest purpose. They have a certain all-round poise or balance called common sense. They

have acquired through long training those habits both mental and physical which make them masters over themselves; and at all times they have the firm determination to pay the price for success in hard work and self-denial.

It is singleness and earnestness of purpose that constitutes the great motive power back of most successful men, and it is a notable fact that the moment a young man becomes animated with such a purpose, that moment he ceases to believe in the elective system, and in the loose college discipline.

In all earnest enterprises which the students themselves manage, they throw the elective system to the winds, and adopt methods and a discipline quite as rigid as those prevailing in the commercial and industrial world.

The boy who joins the football squad is given no sixty cuts a season, nor is he allowed to choose what he will do. He does just what someone else tells him to do, and does it at the time and in the manner he is told, and one or two lapses from training rules are sufficient cause for expulsion from the team or the crew.

I say in all seriousness that were it not for a certain trickiness and a low professional spirit which has come to be a part of the game, I should look upon football and the training received in athletics as one of the most useful elements in a college course, for two reasons: first, because in it they are actuated by a truly serious purpose; and second, because they are there given, not the elective idea of doing what they want to, but coöperation, and coöperation of the same general character which they will be called upon to practice in after life.

Is not the greatest problem in university life, then, how to animate the students with an earnest, logical purpose?

In facing this question I would call attention to one class of young men who are almost universally imbued with such a purpose; namely, those who, through necessity or otherwise, have come into close contact and direct competition with men working for a living. These young men acquire a truly earnest purpose. They see the reality of life, they have a strong foretaste of the struggle ahead of them, and they come to the university with a determination to get something practical from the college training which they can use later in their competition with men.

They are in great demand after graduating, and as a class make themselves useful almost from the day that they start in to work.

Neither their earnestness of purpose, however, nor their immediate usefulness, comes from any technical knowledge which they have acquired while working outside of the university, but rather from

having early brought home to them the nature of the great problem they must face after graduating. Nothing but contact with work and actual competition with men struggling for a living will teach them this. It cannot be theorized over or lectured upon, or taught in the school-workshop or laboratory.

I look upon this actual work and competition with men working for a living as of such great value in developing earnestness of purpose that it would seem to me time well spent for each student, say, at the end of the Freshman year, to be handed over by the university for a period of six months to some commercial, engineering, or manufacturing establishment; there to work as an employee at whatever job is given him, either manual or other work. He should have the same hours and be under the same discipline as all other employees, and should receive no favors. Moreover, he should be obliged to stay even a longer time than six months unless he has in the meantime given satisfaction to his employers.

I believe that there would be but little difficulty in obtaining the coöperation of our business and manufacturing establishments in carrying out this plan, and the University of Pennsylvania, situated as it is in the foremost manufacturing city in this country, would have an especially good opportunity to inaugurate it.

My belief in the benefits to be derived from doing practical, every-day work early in the college course is not the result of a theory. It is founded upon close observation and study of young men who have had this experience, and also upon a vivid remembrance of breakfasting each morning at five-thirty and starting to sweep the floor of a pattern shop as an apprentice some thirty-two years ago, after having spent several years in preparing for Harvard College. The contrast between the two occupations was great, but I look back upon the first six months of my apprenticeship as a patternmaker as, on the whole, the most valuable part of my education. Not that I gained much knowledge during that time, nor did I ever become a very good patternmaker; but the awakening as to the reality and seriousness of life was complete, and, I believe, of great value.

Unfortunately, laboratory or even shop work in the University, useful as they are, do not serve at all the same purpose, since the young man is surrounded there by other students and professors, and lacks the actual competition of men working for a living. He does not learn at college that on the whole the ordinary mechanics, and even poorly educated workmen, are naturally about as smart as he is, and that his best way to rise above them lies in getting his mind more thoroughly trained than theirs, and in learning things they do not

know. All of this should be taught him through six months' contact with workingmen.

Let me repeat in conclusion that our college graduates are the best picked body of men in the community. Yet I believe that it is possible to so train young men that they will be useful to their employers almost from the day that they leave college; so that they will be reasonably satisfied with their new work instead of discontented; and to place them, upon graduating, one or two years nearer success than they now are; and that this can best be accomplished by giving them an earnest purpose through six months' contact early in their college life with men working for a living; by rigidly prescribing a course of studies carefully and logically selected, and with some definite object in view, and by subjecting them to a discipline comparable with that adopted by the rest of the world.

Philadelphia possesses and is proud of the most notable group of medical schools in this country, and among these that of the University of Pennsylvania unquestionably stands first.

The Philadelphia lawyer has been proverbial for his knowledge and shrewdness for more than a century, and this reputation can be traced largely to the fundamental training given in the law school of the University of Pennsylvania.

Philadelphia is the center of the largest and most diversified group of engineering and manufacturing enterprises in this country. The Engineering Schools of the University of Pennsylvania already stand high; but it seems to me that the opportunity lies open to them even more than to their famous medical and law schools to stand at the very top. This magnificent building, equipped as it is with the latest and best of everything, is the first and a great step toward this end. But after all, your largest possibility and one which does not exist for, and cannot be created by any other American university, lies in the opportunity for bringing your students into close touch and personal contact with the men who are working in and managing the great industrial establishments of Philadelphia.

DISCUSSION

THE ART OF CUTTING METALS

By Mr. F. W. Taylor, Published in November Proceedings

Mr. Henry R. Towne Mr. Taylor's paper on "The Art of Cutting Metals" is a masterpiece. Based on what is undoubtedly the longest, largest, and most exhaustive series of experiments ever conducted in this field, its summary of the conclusions deduced therefrom embodies the most important contribution to our knowledge of this subject which has ever been made. The subject itself relates to the foundation on which all of our metal working industries are built.

2 About 60 years ago, American invention lifted one of the earliest and most universal of the manual arts from the plane on which it had stood from the dawn of civilization to the high level of modern mechanical industry. This was the achievement of the sewing machine. About 30 years ago, American invention again took one of the oldest of the manual arts, that of writing, and brought it fairly within the scope of modern mechanical development. This was the achievement of the typewriting machine. The art of forming and tempering metal tools undoubtedly is coeval with the passing of the stone age, and therefore in antiquity is at least as old, if indeed it does not outrank, the arts of sewing and of writing. Like them, it has remained almost unchanged from the beginning until nearly the present time. The work of Mr. Taylor and his associates has lifted it at once from the plane of empiricism and tradition to the high level of modern science, and apparently has gone far to reduce it almost to an exact science. In no other field of original research, that I can recall, has investigation, starting from so low a point, attained so high a level as the result of a single continued effort.

3 Measured by originality and comprehensiveness Mr. Taylor's paper undoubtedly is the most important thus far contributed to the Transactions of this Society. With perfect modesty it makes no claim to sole credit for the achievements it records, awarding due praise to all who were associated in the work, and recognizing that the work itself was made possible by the rapidly developing opportunities which modern materials, processes, and machines have made available, but which previously had not been fully appreciated or utilized.

To Mr. Taylor is due all credit for being among the first to perceive these opportuntities, to appreciate their possible significance, and, with endless patience and consummate skill, maintained through 26 years with unfaltering persistence and despite all discouragements, to carry forward his undertaking to its successful issue.

4 The title of Mr. Taylor's paper does scant justice to the scope of the work which it records, for incidentally to its main purpose this work included subordinate investigations hardly less radical, even if of less importance, than the main issue. Chief among these was the development of what is now best known as the "Taylor System" of shop management, itself a discovery of fundamental importance, the influence of which will be felt ultimately and permanently, not only in the metal trades but probably in all organized industry. Less fundamental, but still of universal interest and value wherever power is transmitted from a central source to large groups of power-driven machines, is the determination by Mr. Taylor of more correct and efficient rules for the use of leather belting than were previously known. Another distinctive topic covered by his work is the proper forms of cutting tools and improved methods of making and maintaining such tools. Still another, and in some respects the most novel and brilliant of these many contributions to technical knowledge, is his adaptation of the slide rule to the determination of equations involving twelve variables, by a process so simple as to bring it within the reach of any skilled mechanic of fair intelligence.

5 The Society of which Mr. Taylor is the President, the profession of which he is an honored member, and the industrial world are all to be congratulated on the achievements of which Mr. Taylor's paper, voluminous and comprehensive as it is, constitutes but a partial and inadequate record. While probably that paper is by no means the last work to be spoken on the subject to which it relates, certainly it is the most important and authoritative which has yet been uttered.

MR. JAMES M. DODGE I want to just say one word about one word, and that is the word "task." It is a pity that our language has not got another word that is more applicable to the meaning that Mr. Taylor gives to the word, but Mr. Taylor agrees with me that our language does not give us the exact word needed. Now, the "task" set by the Taylor System isn't a club which makes a man do twice as much as he did in the same way he has been doing it. The "task" set by Mr. Taylor, by the use of the prescribed tools and methods, lightens the task; it does not add to the labor performed. It cuts out the unnecessary motions, and it renders the motions made more

useful and more efficient by something supplemental. These motions are made, if we can use such an expression as suiting a man's comfortable position or accomplishments. The men themselves who are doing these "tasks," say that they go home less tired than they used to do when they set their own tasks. So I say again that I regret that we have not a better word than task which according to our childhood lessons implies bother or burden, something which our teachers meant as a punishment to us. It is not a task; it is a help to the employee.

MR. CALVIN W. RICE As an incident to the introduction of system in a certain shop it became necessary to conduct the experiments of which the presidential address is a résumé. I say an incident, but it would probably be more correct to speak of the address as a record of many incidents to the introduction of the Taylor system.

2 The system is universal of application, and the mastery of the art of cutting metals was simply one of many things to do to make a success of the system. As the system is applied to other industrial establishments, we may in turn expect papers on the arts pertaining to them, such as the art of bleaching cotton goods, etc.

3 This situation is not peculiar to the Taylor system. Mr. Edison has been busy the last few years not so much in inventing a storage battery as in the development of the art of the manufacture of materials that go into the composition of the battery. Were it not a digression I would like to go into the subject in detail.

4 Therefore the good from modernizing engineers is far reaching. This fall I had the opportunity to visit the Sayles Bleacheries, located near Pawtucket, R. I., where the Taylor system is being introduced, and with your permission, I will offer as a discussion on this paper, a few remarks on what I saw there, the object being to show the applicability of scientific method and the benefit derived from such application to any form of industry.

5 It is well to observe here that one cannot effect these improvements without, first, complete submission of the management of affairs to the one introducing the system, and, second, additional people to the regular establishment. There is no compromise between the old and the new because they are fundamentally opposed. It is only folly to try it because it is a physical impossibility for the regular staff both to conduct the regular business and simultaneously master and apply the new system.

6 In the Sayles Bleacheries I was permitted to compare the record of the output of certain rooms before they began to introduce the

system with what is now being done, and even in the most simple matters, namely, folding cloth, the increase in output was very great, individual cases fivefold, and the increase of individual wages 20 to 40 per cent. The cost per piece was of course reduced.

7 Improvements in other bleacheries, competitors say, have of course been going on also, so that the Sayles have no monopoly in this regard, but what they do have over their neighbors is a better class of employees with higher individual wages, freedom from labor difficulties, because the Taylor system does not conflict with the bulls of labor unions, and more than all, an organization capable of indefinite expansion to meet any emergency.

8 It would be out of place, and perhaps breach of confidence to go into further details. Suffice it to say, that in this world of competition intelligent organization based on scientific investigation is the *sine qua non* of success and that no amount of work or years of investigation necessary to obtain the result should deter the investigator.

MR. J. SELLERS BANCROFT I wish to add a little contribution to the historical side of Mr. Taylor's paper, with reference particularly to the shape of the cutting tool, and the means for producing it.

2 In 1869, I made a number of experiments at the works of William Sellers & Co., where I was then shop foreman, and demonstrated that the round-nosed tool would take a cut having a feed from 25 per cent to 33 per cent coarser than the diamond point tool would take in the same material and same depth of cut, with the added advantage that on cast iron the final chip being so much thinner the material was left in much better shape for the finishing tools. The advantages of this form of tool, and the importance of having uniform angles of clearance and top rake, demonstrated the importance of having these tools ground by machine, and in 1874 Former slide rests, arranged to attach to regular grindstone boxes, were put into service and used regularly for this purpose. The advantages of this system were so apparent that in 1884 a more fully organized machine was constructed, using a special form of emery wheel on which all tools used on the machines, whether for lathe or planer, external or internal work, or screw cutting, could be finished to definite angles and sizes, and thereafter all tools used in the shops of William Sellers & Co. were so ground.

In 1883 a long series of experiments were tried on a 48 inch lathe to determine the power required for various depths and widths of cut on both steel and cast iron, and the information thus gained was used thereafter in the designing of machine tools.

So far as I know, Mr. Taylor is undoubtedly the pioneer in experiments leading up to the discovery of the conditions which permit the use of high speed in cutting metal, both as relates to the shape of the cutting tool and the relation of depth of cut to feed and the method of producing high speed tools, which discoveries have practically revolutionized machine shop practice. But I think that the changes made by Mr. Taylor in shop management and methods of handling work have been far more important, as regards the increased production of any given machine, than the cutting tools themselves, important as they are.

MR. H. K. HATHAWAY It is to be hoped, and is highly probable, that many superintendents and managers of machine shops will undertake to make use of the invaluable data that Mr. Taylor has so generously made available to thousands, who, through limited facilities and time, would otherwise be unable to acquire more than an inadequate and superficial knowledge of this vitally important branch of manufacturing, and that as a result the manufacturing world may be as greatly benefited by exact knowledge of what can be accomplished in cutting metals, as it has already been benefited through the invention and general use of high speed steels.

2 I should like, however, to call attention to a grave danger that will confront all who undertake to attain the results that Mr. Taylor has shown to be possible, which, unless properly guarded against, will cause all such attempts to end in disastrous failure and disappointment. This danger is, that despite the fact that Mr. Taylor has clearly stated the necessity for first establishing such conditions as will make it possible to always and definitely answer the "questions which must be answered each day in every machine shop," as to the kind of tool, the feed, speed and depth of cut to be used, and to make use of the answer after it is given, many will undertake to apply the knowledge contained in Mr. Taylor's paper without any preliminary preparation to insure the successful outcome of such an attempt.

3 In many cases such an effort will cease after the workman running the machine, when told to use a certain feed, speed, or depth of cut, replies in a convincing manner that the machine won't stand it, or that the job he is working on is of such a peculiar nature that such a heavy cut would spoil it by "springing" it or making it come "out of round." If the foreman is still unreasonable enough to insist upon his trying it, he will either quit, or proceed, more in sorrow than in anger, to prove the truth of his statements, and the foreman will probably lose heart after the following things happen: The cone belt

will slip and have to be tightened; next the countershaft belt will slip and have to be tightened, then if the belts pull the cut without breaking in two or pulling out at the lacings, it will be found that the carrier, driver or chuck will not hold the job.

4 After surmounting these difficulties and having the tool break or fall down through having been improperly treated and ground, the foreman will find that for about three hours he has neglected important matters in other parts of the shop and will conclude in the future to mind his own business and leave such matters as feed and speed to the judgment of the man running the machine, who from his daily experience ought to know better what the machine and tools will do than anyone else in the shop.

5 Having been through all this myself, I know pretty well the opposition and difficulties that will be encountered, and feel that too much stress cannot be laid on the importance of overcoming them before they have a chance to arise, and I have become a strong believer in the "ounce of prevention" theory, provided it is applied, not in a spasmodic manner, but systematically and continuously.

6 To cite an instance of what may be expected when one undertakes to speed up the average shop, I should like to mention an experience of my own that happened a few years ago, when after having passed through the various stages from apprentice to foreman, or "overseer," in the machine shops of the Midvale Steel Company, where I was accustomed to see rapid and heavy cutting, and also men obeying orders as to speeds, feeds, etc., and to have belts heavy enough and maintained to a tension that assured their pulling all that the tool would stand, I accepted a position as superintendent with a small concern, where the workmen, under the sole direction of one "overworked foreman," ground their tools to suit themselves, repaired and cared for their own belts, and followed their own judgment or inclinations as to the feeds, speeds, cuts, and kind of tools to be used.

7 I was amazed at the light cuts and slow speeds I found in vogue, as well as the many peculiar shapes of tools in use, and attempted at once to get things up to the speed that I had been used to at Midvale, with the result that I encountered all the obstacles previously enumerated and found that the custom in that shop, when a belt slipped, was to reduce the speed or feed to a point where it would pull, as the workman reasoned that it was less trouble to do so than to tighten the belt.

8 Another drawback to using the proper feeds and speeds was that the tools were of every conceivable shape and kind of steel, a

bar or two having apparently been bought from every tool steel salesman who came along, and as the workman had no means of identifying the tools made of good high speed steel from those made of old carbon or early self-hardening steels, he ran the speed suited to the latter, to be sure that his tool would not give out during a cut.

9 After I had managed to get the belts, tools, and driving mechanism on a few of the machines in such a condition that something like the proper speeds and feeds could be used, I found that it was utterly impossible, with one "overworked foreman," (who did not take very kindly to my notion of speeding up, anyway), to insure such conditions being maintained continuously, and that while I might get a workman to run the proper speed on a certain job today, that if left to himself the next time that job came up he would be running the same old speed and have the same old reasons for doing so.

10 About this time I learned another fact that has since been of great value to me, and that is, that it is exceedingly unwise to expect to attempt to correct the evils of years of bad management and faulty shop practice, or to bring about a change from the minimum of efficiency to the maximum of efficiency in a few days or weeks or even months.

11 In the shop referred to, I attempted to install the premium plan, based on carefully kept records, which I later found to be absolutely inaccurate and unfair, and to get the shop up to the speed that I knew to be possible, in about three months' time, with the result that at the expiration of that time I had a strike on my hands which pretty nearly put the company down and out, and solely because I began at the wrong end, instead of first taking steps to insure the success of my efforts; first, by standardizing, and making such improvements in the belting, tools, and appliances as were necessary in order to make it possible to get the same results as were being attained at Midvale; secondly, by providing a system or mechanism for keeping them up to the standard once attained; thirdly, by replacing the one "overworked foreman," who was expected to know it all and do it all, by a planning department which would each day assign for each workman a definite task to be performed in a definite time, and prepare instruction cards showing just how each job should be done and what speeds, feeds, and tools should be used, and by several functional foremen in the shop, each of whom would have specific and well-defined duties, for which his temperament and training fitted him; who would coöperate in seeing that all work was done in the manner planned and that the standards were maintained.

12 It seems to me that my undertaking to apply in this shop, the feeds, speeds, and cuts that I had used, and seen used continuously at Midvale, is analogous to undertaking to apply the information on the "Art of Cutting Metals" contained in Mr. Taylor's paper, in the average machine shop without any previous preparation to insure a successful outcome of such an undertaking, and it is devoutly to be hoped for their own sakes, and in fairness to Mr. Taylor, that all who do hope to benefit by Mr. Taylor's vast experience in this line will begin at the right end and in the right way which Mr. Taylor has pointed out and which I am convinced, from my experience in the matter, lies in the application of the principles set forth in his paper on "Works Management," and which can only be successfully applied through a system of functional management, where every man from the manager down has a definite task to perform in a definite way and by the establishment and maintenance of rigid standards.

13 Unfortunately such a system as Mr. Taylor's cannot be bought and delivered in a box, but must be installed step by step until the final goal is reached, when a definite task is given each workman each day in advance with detailed written instructions and an exact time allowance for each element of the work, and this installation calls for such an amount of hard work, close and incessant following up, and minute study of conditions as to make it impossible for any man who has routine work to do in connection with the running of a plant, to undertake it with any hope of success, but will call for the undivided attention of an experienced man, who must have the heartiest and most sincere backing and support of the management in the face of the opposition and prejudice that is sure to be encountered. Even then, there will be times during the period of revolution from the old to the new system of management, when it will appear as though the business is going to ruin, when the greatest faith in the soundness of the principles upon which this system is based will be required to carry one through them, but the reduced costs, increased output and harmony that are bound to result in the end are sure to pay many times over for the labor and expense incurred in making the change.

MR. JOHN T. HAWKINS Nothing but admiration can be entertained for the indefatigable, exhaustive, and methodic work set forth in President Taylor's paper, extending as it has through so long a period of time, on the somewhat narrow question, however, of how best and most economically to rough out, preparatory to the finishing processes, castings of iron and steel, or forgings of the latter metal of

considerable dimensions; for to these the paper seems to be confessedly and practically confined.

2 There is in it, however, for me, a most regretful feature, which is, that if carried to its logical conclusion it would ultimately eliminate, or at least very greatly emasculate the real mechanic.

3 The writer's immediate progenitor was of that old school of mechanics scarcely now known in the industrial world except by name, as the all 'round man. He was at once a blacksmith, machinist, and pattern-maker. He could do a job in the foundry when necessary and was no slouch as a draughtsman. He could forge an anchor or make a violin; and what's more, could creditably perform upon the fiddle when finished.

4 It was in the shops of such a father that the writer imbibed much of what has now become scarcely more than memories and is well nigh obsolete in the mechanical world of today, and what certainly contrasts greatly, so far as physical and mental capacity of workmen is concerned, with the quality of mechanic that would suffice under the slide rule system described by Mr. Taylor.

5 Time was when what has been felicitously termed "finger wisdom," coupled with the ordinary complement of brain, constituted the productive capital of the mechanic. These joined to that salutary disposition in a workman to industriously apply those attributes to the production of the most and the best; that carrying of their consciences with them when they went to work in the morning which obtained in the older days, presented a state of things in industrial concerns such as no longer obtain to any satisfactory extent; it is with regret, therefore, that the writer sees, or thinks he does, in the adoption of such a system as is illustrated by Mr. Taylor, an inevitable tendency toward the supplanting of the old-time finger wise and thinking mechanic with scarcely more than unthinking automata; and I have great fears that to thus narrow down and circumscribe the man would be disastrous in the long run.

6 Of course, I have long ago realized that in these days of labor-saving machinery and division of labor such a type of mechanic as I first described would be in any modern establishment a most expensive superfluity, if not indeed an impossibility; and I am very far from advocating that every mechanic should now be expected to "know it all." In this specializing age I recognize that both the maximum of productivity and perfection of work come greatly from narrowing the field of a mechanic's activity; as indeed obtains in the professions and in every sphere of human endeavor; and the fact is, that during the last 50 or 60 years so much has been added to

the sum of human knowledge that in the machinist's vocation alone, the total has become too great for the average man to master and to perform well and profitably. It is no less essential, however, that the mechanic should still be, to whatever comparatively narrow field he might be confined, an intelligent, brainy, finger wise man. It would generally, and in the long run be vastly better for all concerned, even if a man learned nothing more of a machinist's vocation than would pertain to the roughing out of heavy work of iron and steel on the appropriate machine tools, with his cutting tools all chosen, fashioned, and ground for him, as has long been the practice in the best shops as a branch of tool room work, to learn this well and all that is implied in and pertains to the art of such roughing; to become finger wise and head wise in his chosen narrow occupation, than to have his mental efforts confined to so narrow a limit as is involved in the slide rule system described.

7 It seems also quite obvious that the highest productivity and pecuniary advantage both to himself and his employer ought to be more likely to come from the conscientious work of such a man who learned to rely upon his own head and his own hands, than from one only so poorly equipped as would be necessary where he depended upon these slide rules to do his thinking for him.

8 The writer's sympathies with the competent, thinking mechanic are so great that he prefers to believe that in the long run there is much more to be looked for in the furtherance of the productivity of any machine or set of machines through some such system as will be described at a later session in a paper by Mr. Magnus W. Alexander, entitled "A Plan to Provide a Supply of Skilled Workmen," the system being in operation at the Lynn works of the General Electric Company, and in similar systems which are in operation in other parts of the country, than can possibly, in the long run, result from such as the slide rule system in question.

9 There is, however, one aspect of this matter which leads the writer to look upon the narrowing, emasculating feature of this slide rule system with more toleration than he could otherwise do; and to choose, as it were, between two evils.

10 Such a system, if it could be carried extensively into use in the machinist's vocation, and made to appeal, as it may, to a man's cupidity, would have such an effect upon the horrid work of the labor unions as in due time to put them practically out of business, and render what is known in trade union parlance as the "closed shop"—most appropriately and expressively so named—a curiosity.

11 If a man whose capacities were only sufficient to operate under

the slide rule system were told that he could get a job, where, while increasing his employer's profit by 40 per cent he could add to his own receipts 35 per cent, provided of course he subject himself to the orders of his employer in preference to and in place of those of any union, he would be reasonably sure to jump at such a chance; and the more certainly if he remembered that he could save in addition all fees, dues, fines, and assessments demanded and enforced by his union.

12 The writer has for a long time been as deeply interested in the suppression of closed shop unionism as he always has been in the elevation of the competent mechanic and workman. As a typical case let me relate that while managing engineer of a concern running a machine shop employing about 100 men, as an adjunct of an extensive special business, I was also a minority stockholder in the whole concern. The majority powers, after a long struggle, consented to the making of the whole industry a "closed shop."

13 I may say here in parenthesis that had I been a majority stockholder you may depend that it never would have become a closed shop.

14 Soon after this change was effected in watching a man running a milling machine, I found that he was using a feed which my experience of more than 50 years, both as a workman and employer, told me was more than four times too slow. In short, that when the extra cutter grinding made necessary by this mere scraping process is considered, this man was in receipt of about five times more than he really earned while making five machines necessary to do the work of one.

15 Suffice it to say that when he was remonstrated with by me I was referred by him to the "shop steward," an official of the union empowered to regulate all such questions and to keep the product down to a labor union standard. Suffice it again to say (and in order to forestall my friend Mr. William Kent, who is very likely to ask why I did not do something about it) that after all possible persuasion on my part to prevent the establishment of the closed shop, without avail, I very soon thereafter resigned my position and sold my stock to the then majority holders, rather then continue a party to such a state of things.

16 Now, I can readily conceive that if the slide rule system of Mr. Taylor was applied to such as this man and to men in the many other variations and ramifications of the machinist's vocation, such an outrageous state of things as I have just described would soon become impossible; but I am afraid that we could never hope for

such an extended application of that system as would become necessary to that end; and if we could thus extend the system, who is there of us, rejoicing in the title of mechanic, or machinist, or engineer, if you will, to complacently witness such a change? For myself, I feel that it would not be a consummation very devoutly to be wished.

17 I have become so greatly impressed of late years with the great necessity for an intelligent and earnest crusade in the direction of educating the coming generation of mechanics up to their own best interests and capacities, as the most efficient barrier to the growth of trade union evils that I look with suspicion upon anything which may tend to lower his mental status; and but for the extent to which I have fallen into "the sere and yellow leaf" after more than 60 years of active effort as machinist, engineer, and employer, always striving to make two blades of grass grow where before grew but one, that it has become quite an impracticable thought for me. If I could, I should try to revolve backward, as it were, in more respects than one and endeavor to restore something more of the old-time conscientious, faithful, intelligent, finger and brain wise mechanic.

PROF. L. P. BRECKENRIDGE We must certainly be greatly impressed with the magnitude and value of the work which has resulted in the paper presented to the Society by President Taylor on the subject "The Art of Cutting Metals." The Society is to be congratulated in being able to present to the manufacturing industries of the world the invaluable material now so generously contributed by Mr. Taylor and his associates. We have all been allowed glimpses of this work from time to time and have marveled at even some of the smaller details, but when we come to look down the long vista of 26 years and realize to some extent the immense expenditure of time, money, and effort, the careful, minute, painstaking researches and patient devotion of noted specialists, all gradually leading to this final monumental accomplishment, and when we realize what it all means to the future advancement of industrial works, we must acknowledge that the work presented will doubtless be a classic in this particular field of engineering literature for many years to come. The possibilities of coöperation as pointed out by Mr. Taylor have been taken advantage of in a most admirable manner, and we must express the feeling that only a man of extraordinary patience, ability and tact could have been the guide and inspiration of this intricate task.

2 The reference of Mr. Taylor to the work undertaken by the Engineering Experiment Station at the University of Illinois by Mr.

H. B. Dirks and myself is appreciated. We realized at the time and realize to a much greater extent now, the insignificance of our contribution to this subject. We did have, however, two important thoughts in our minds in connection with our work:

a That Illinois industries were not taking advantage of the opportunities offered by the use of modern high-speed steels, and that our manufacturers could be educated to the fact that cast iron could be turned more rapidly than had been the previous practice. We felt that their attention could be called to its possibilities by a series of experiments such as were published, even if they did not settle many of the important problems connected with the use of high speed steel.

b We were desirous of placing before the students of the College of Engineering a working illustration of the use of high-speed steels in cutting metals.

3 It is possible that these two objects were in a measure accomplished. Although we spent but about 14 months, and expended only about $2500 on our work, we did go far enough to appreciate the impossibility of any one experimenter accomplishing very much, as is corroborated by Mr. Taylor in his present paper.

ON THE EVOLUTION OF GAS POWER

By F. E. Junge, Published in November Proceedings

Prof. H. Diederichs The presentation of the subject, in general, is so complete that little can be added. The great importance of the gas power question is conceded, and the recent placing of large orders for Loomis-Pettibone producers with the Power and Mining Machinery Co., and for Allis-Chalmers blowing engines by the Carnegie Steel Co., would seem to show that our own power users have not only considered, but have already very largely decided the question for themselves.

2 The writer is in thorough accord with the statements made regarding the Brayton, now the so-called Diesel cycle, the possibilities of the constant pressure gas engine having up to this time not been fully realized. It is true that Diesel carried the oil engine, working on this principle to a degree of perfection never before attained, but the oil engine is limited in its capacity owing to the difficulty of satisfactory combustion in large cylinders. The constant pressure gas engine has never been developed to the extent that the promise of its cycle seems to warrant. Of course, it is

realized that there are serious difficulties connected with the handling of comparatively large bodies of gas under high pressures, but producer gas, and not oil, will be the fuel of importance and hence the constant pressure gas engine seems worthy of a little more attention than it has so far received.

3 The computations made by Mr. Junge on type cycles in the appendix of the paper are of interest and show in a limited way the relation between the constant volume, or Otto, and the constant pressure, or Brayton, cycle for the conditions assumed. To get a clear insight into this relation for himself, the writer in 1904 constructed a three-dimension diagram, published in the Sibley Journal, which may prove of interest.

4 It can be shown that the efficiency of the ideal Otto cycle is in general

$$E = 1 - \frac{1}{r^{n-1}}$$

and that of the constant pressure cycle is

$$E_1 = 1 - \frac{1}{r_1^{n-2}} \qquad \frac{(d^n - 1)}{n(d - 1)}$$

5 In these equations, r or r_1 = compression ratio

$$= \frac{\text{stroke volume} + \text{clearance volume}}{\text{clearance volume}}$$

n = exponent in the equation $pv^n = \text{const.}$ for the compression line.

and d = cut-off ratio in the constant pressure cycle

$$= \frac{\text{volume at cut-off}}{\text{clearance volume.}}$$

6 Now it is evident from an inspection of the two equations that for the same values of r and n, that is, for the same compression pressure, E will always be greater than E_1. But in practice the operating limit is not due to the compression pressure but to the maximum pressure occurring in the cycle. It then becomes interesting to see what the conditions are when maximum pressures are assumed equal in the two cycles.

7 To obtain a basis of comparison the following assumptions were made:

a The maximum pressure in each cycle is 25 atm. (352 pounds per square inch.)

b Value of $n = 1.37$, an average figure.

c Each cycle is assumed to receive the same quantity of heat, *i. e.*, that necessary for the nominal horse power under the conditions chosen.

d The temperature at the beginning of compression is assumed at 600 degrees Fahr. absolute.

8 The diagram, herewith, shows the result of these computations. Efficiencies are plotted from bottom to top. From right to left are given values of d, and from front to back values of r or r^1. In this case r stands for the ratio of compression in the constant pressure cycle, while r^1 represents the equivalent ratio of compression required in the constant volume cycle. As an example, if $r = 10$ for the constant volume cycle, the Otto cycle for the same maximum pressure, *i. e.*, 25 atm., and the same amount of heat furnished, would have a ratio of compression $r_1 = 4.9$

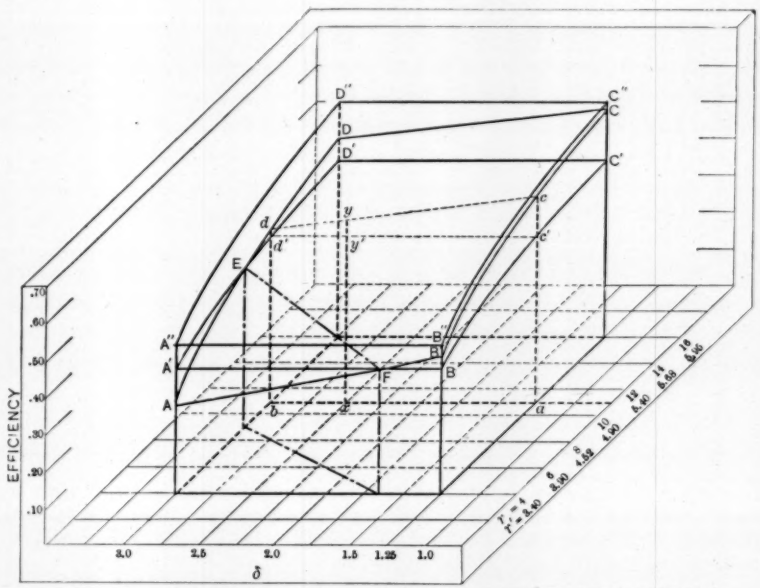

FIG. 1 DIAGRAM SHOWING EFFICIENCIES OF THE OTTO CYCLE

9 In the figure, the surface *A B C D* represents all the possible efficiencies of the constant pressure cycle for the ranges of r and d covered. In the same way the surface A_1 B_1 C_1 D_1 shows the efficiencies for all the possible constant volume cycles. The factor d does not appear in the equation for this cycle, hence the effici-

encies are constant in this direction. The two surfaces intersect in the line *E F*, and for the conditions assumed, therefore, the constant pressure cycle is superior to the constant volume cycle for all cycles in the surface *F E D C B F*. In the only commercial constant pressure engine, the Diesel, the value of d at full load is about 2.5, and r is in the neighborhood of 13. It is seen from the diagram that the superiority of the constant pressure engine is considerably under these conditions. In making comparisons by this diagram it should, however, not be forgotten that the cycles treated are ideal, and that in practice, while the results are similar, the gain due to the constant pressure principle is probably not so great as indicated.

10 The diagram is drawn by isometric projection, and to show how comparison may be made by means of the diagram, assume that the constant pressure engine has a compression ratio of $r = 11$. The equivalent ratio for the constant volume cycle of the same maximum pressure (25 atm.) and the same amount of heat received would be about $r_1 = 5.15$. Assuming full load conditions, *i. e.*, $d = 2.5$, we proceed as follows:

11 From $r = 11$, draw a line *a-b* parallel to the d axis. From *a* and *b* draw lines parallel to the efficiency axis cutting the curve *B C* in *c* and the curve *A D* in d; join *c* and d. Then from the point of intersection of $d = 2.5$ and the line *a-b* draw the line *x-y* parallel to the efficiency axis. The distance *x-y* as scaled off on the efficiency axis represents the efficiency of the ideal constant pressure cycle for the conditions assumed. Next, join the points d^1 and c^1 which represent the intersection of the lines *a-c* and *b-d* with the limiting curves of the constant volume surface. Then *x-y* represents the corresponding efficiency of the constant volume cycle. As scaled off, *x-y* = 50 per cent and *x-y*^{1} = 46 per cent. Actual computations show the figures to be 49.8 per cent and 45.6 per cent, respectively.

12 The diagram further brings out the fact that, in theory, the efficiency of the constant pressure cycle increases with a decrease in d, that is, with a decrease in the load. This is borne out in practice in Diesel engines, where many tests have shown a greater thermal efficiency at $\frac{3}{4}$ than at full load. Further down in the load curve this action is overbalanced by other losses in the machine and it no longer appears.

13 Finally, the surface *A″ B″ C″ D″* represents the efficiencies of the constant volume engine when the compression pressure is the same as in the constant pressure cycle; *i. e.*, r is the same for

both. As pointed out, this results in superior efficiencies for the Otto cycle throughout, but in the ordinary operation of the Otto cycle, pre-ignition would prevent the uses of values of r exceeding eight even for the lean gases.

MR. J. E. JOHNSON, JR. No one who has read this paper carefully can fail to realize that the author had an exceptional grasp of the subject and has treated it along broad lines.

2 There are some points to which I wish to call particular attention in relation to this general subject. My particular reason for desiring to be heard in this matter is that it concerns itself intimately with the engines of blast furnaces, and being one of the few blast-furnace men who are members of this Society, it is possible that I can throw a little additional light upon the subject.

3 In the first place it seems permissible to call attention to the Appendix of Mr. Junge's paper and particularly to the comparison of the theoretical efficiency of two cycles, first, the ordinary Otto cycle, and, second, the cycle of the controlled combustion motor of which the Diesel is the most prominent type, paragraphs 85 and 88. It would seem that the theoretical efficiency of the controlled combusbustion type is 55.6, while that of the Otto is 51.4 per cent; on the other hand the maximum temperature of the Otto is 2348 degrees as against a maximum temperature of 1954 degrees in the controlled combustion type. As the high temperature reached by the internal combustion engine presents one of the most serious obstacles in its design, it is not easy to see why the controlled combustion type has not beaten the Otto cycle off the field altogether, and as things in engineering are, in general, most successful which conform the most closely to natural laws, these figures seem to indicate that the ultimate development of the gas engine will be more in the direction of the Diesel type with its great resemblance to the diagram and characteristics of the steam engine, than in the direction now so strenuously pursued.

4 This is more particularly true if we consider one of the possibilities of power transmission of which no mention has as yet come to my attention. This consists in the transmission of combustible gas under such initial pressure that the discharge or terminal pressure will be high enough to be used directly or with slight additional compression in the cylinders of a Diesel engine, the advantage being that all ordinary piping is strong enough to carry many times the ordinary pressures used and the necessary precautions for making tight joints at this high pressure do not increase the cost of the line in anything

like the degree that the increased pressure augments the carrying power of the pipe.

5 It is a fact not generally appreciated that gaseous friction in pipes depends, under given conditions, upon the difference of the squares of the initial and terminal pressures. Thus the drop in pressure from 500 pounds down to 400 pounds would convey the same quantity of air as would be conveyed by the drop in pressure from 300 pounds down to atmospheric. The insignificant increase in power to compress to 500 pounds instead of 300 pounds is perfectly well known, and the net result is that for a slightly great expenditure for pipe line and for energy of compression, we should have gas delivered at a pressure which would enable it to be used directly in the cylinder of a Diesel engine without further compression, making a great simplification of the engine and giving an enormous capacity of transmission to a pipe line of very moderate size.

6 In considering the general subject of cheap power development and its cheap transmission from coal fields to points of consumption, a scheme of this kind is worthy of the most careful consideration; the facts being that the efficiency of compressed gas transmission as compared with that of electricity is very much higher than is generally appreciated. As regards the general subject of the use of gas engines in place of steam engines, especially in connection with blast furnaces, many extravagant claims have been made—statements totally out of range of a reasonable possibility, and Mr. Junge, himself, has stated that the gas consumption for a given power was as 1 to 3 in favor of the gas engine as compared with the steam engine. It is statements of this kind and of the more exaggerated kind, just mentioned, to which I desire to take exception.

7 Mr. W. H. Booth, of London, generally so edifying and informing in all that he writes, recently made the prediction that the blast furnace would eventually come to be used as a gas producer first and as an iron producer secondary, the iron being a by-product; while "Power," one of the best edited of all the technical journals, recently had a pair of comparative pictures on its front cover, one showing an open top furnace of a kind which has not been common for more than 40 years and in the other the gas-electric plant and its magnificent transmission system. The impression left in the mind of the casual beholder would undoubtedly be that until the advent of the gas engine, the conditions presented by the other picture had prevailed.

8 Mr. Junge also in paragraph 22 says: "These gases were formerly wasted either by inefficient methods of transformation or by

blowing them into the air. They were, therefore, called 'waste gases' and were marked in the columns of plant economics as having no commercial value whatsoever." As far as blast furnaces are concerned, the top of the furnace has been closed with the purpose of leading off these gases to points of utilization, for 30 years in the writer's personal recollection and for 15 or 20 years before that time. In a broad sense, therefore, both the picture in "Power" and the statement of Mr. Junge are utterly incorrect.

9 As regards the method of transformation it has, in many cases, been very wasteful; the poorest type of boilers, the most uneconomical type of engine being employed at blast furnaces, but as blast pressures have arisen demanding more work from the blowing engine, the economy of the machinery has been increased in much greater ratio, so that for 10 or 15 years past there has been a strongly marked tendency at every works which desired to keep up with the procession, to install an economic type of boiler (generally water-tube) and cross compound condensing blowing engines, with Corliss valve gear, a combination which it is safe to say will yield a horse power with $\frac{1}{4}$ the quantity of gas employed under the old regime.

10 This tendency is so universally prevalent that the standard of comparison with the gas engine, must no longer be the old type of uneconomical boilers and engines, but the best modern type of steam machinery, whose economy would probably be not worse than 16 pounds of water per horse power per hour. That the gas engine has a decided advantage in fuel economy over an engine even of this type is not to be denied, but it seems probable that the advantage is not in the ratio of 3 to 1, as claimed by Mr. Junge, but much more nearly 3 to 2, in other words, instead of saving $\frac{2}{3}$ of the gas used by such apparatus, the gas engine cannot save under commercial conditions probably much more than $\frac{1}{3}$. To account for the apparent disregard of even this considerable saving, it is necessary to realize the conditions of blast furnace operations, a thing which power experts have seldom been able to do.

11 This subject is so large that it is impossible to give an adequate idea of it in a brief discussion of this kind, and it would, moreover, be out of place here. It is, however, safe to say that there is no apparatus in metallurgy in which the capital invested and the value of the output are both so high as in the blast furnace. There is, therefore, a very heavy fixed charge of labor, interest, depreciation, and other factors, amounting to from $1.50 to $2.50 per ton of iron produced, which goes on just the same whether the furnace is in operation or not. In many cases, furthermore, the steel works are an adjunct to the blast

furnace immediately dependent upon it for their operation and having a still larger interest charge against their output. A suspension of operations, therefore, at a blast furnace means not only loss of profit on iron not made, but also the loss of this fixed charge. The result is that the machinery and the furnace must be reliable in the first, second, and third places and economical in the fourth.

12 Any attempt to regard the blast furnace as an adjunct to the power plant may be technically correct but is commercially foredoomed to failure, as the following illustration will show. A certain large steel work in this country has adopted the gas engines for blowing purposes and also for electrical generation: three of the furnaces were connected to the gas main supplying this machinery, two of these, for some reason, which is immaterial to this discussion, went out of commission temporarily, and the third one was supplying gas for the gas engines. It had steam blowing engines, available for its own use, but the furnace superintendent had never caused a shut down to the electric station and he was very anxious not to do so. This third furnace began to show symptoms of those sudden ailments to which blast furnaces are liable, and for the remedy of which a stop was necessary, but the superintendent was determined that he would not shut down the gas engine plant and would not stop this furnace until he could get one of the others into operation. By doing so, he saved the gas engine plant from a shut down, but when the relief furnace was put on the other was in such a state as to demand 10 days of terrific work and expense, with practically no output during that time. As this furnace was probably making in the neighborhood of four hundred tons per day, worth something like $15 per ton at the furnace, the loss of output during this 10 days amounted to $60,000 or thereabouts, while the loss in fixed charges and profits was possibly not less than $20,000. This may be taken as a typical case of a possible occurrence at a plant with gas-driven blowing engines; of course, not a very frequent occurrence but sufficiently expensive in every sense to compensate for its rarity. The benefits, on the other hand, which are to be obtained by gas driven blowing engines through the utilization of surplus power are to be obtained in only a slightly reduced degree by the use of good steam machinery.

13 At the plant of which the writer has charge, we are now constantly on the edge of being short of steam, but we have under construction a cross compound condensing engine of Nordberg build, and have under reconstruction our boiler plant, so that we shall be able to use 125 pounds of steam pressure and will have, when we are done, a first-class plant of water tube and horizontal tubular boilers. We

are so sure that we shall then have a large excess of steam that we now have on the ground, ready for erection, a large air compressor and power engine combined, for transmitting air a mile to the mines, developing power for various purposes, driving the washer, running the pumping plant at the river, running all the shops at the plant, etc.

14 From previous experience with a similar type of blowing engine and much poorer boilers at another plant we are perfectly certain that we shall have ample steam for these purposes, and expect to have available four or five hundred horse power more at the least calculation, all from a 100 ton stack running with a moderate coke consumption. We have under contemplation the erection of an auxiliary plant which will utilize some of this surplus power in addition to the uses already mentioned.

15 Does not this seem very much like the story of the advantages to be obtained by the use of the gas engines? Is not the difference much more one of degree than of kind? Does the gas engine mark the epoch in contrast with good steam machinery or only in comparison with poor? These are questions which will be answered according to the balance between the commercial and the scientific perceptions of each individual. There is no question that for large plants of three furnaces or more, which can safely count on a supply of gas from at least one of these at all times, the gas engine will eventually come to be used for blowing engines and other power purposes, especially if the location of the plant is such as to provide a market for the surplus power thus made available, but at the isolated plant where the engines drive the furnace and the furnace drives the engine, as long as all goes well, they are valuable—but not when things go badly. It would be an intrepid manager who would stake all on the use of a gas blowing engine. Not merely because the gas blowing engine is less dependable than the steam engine (though it undoubtedly still is), but because the supply of gas is liable to fail suddenly just at the time when it is needed most, a condition which can be met in the steam driven plant by simply burning coal under the boilers already in use, but in the gas driven plant it would require the starting of an idle gas producer, with the loss of several precious hours.

16 I may explain that this condition arises from the fact that furnaces sometimes "stick," that is to say, the stock in the anterior of the furnace becomes packed and impermeable to the blast, the pressure rises enormously, and at the same time but little blast forces itself through, cutting off almost entirely the supply of gas from the furnace to the power plant. It is absolutely essential at such times that the engines continue to run against that heavy pressure without a mo-

ment's intermission, under penalty of losses in labor, money, and anxiety, which are frightful to contemplate. It is no exaggeration to say that a three hour loss of time under such circumstances might result in a loss equal to one-half the value of the blowing plant. The furnaceman is compelled on this account to regard machinery, not as an end itself, but as a means to an end, and I have frequently thought that while all well-regulated schools of mechanical engineering should have a course on the scientific use of machinery, all metallurgical schools should have a course on its deliberate, scientific, and commercial abuse. The refinements which constitute the glory of mechanical engineering being utterly insignificant in the presence of the necessities of metallurgy, if considered from the commercial point of view.

17 The time of the gas engine is undoubtedly coming; but let it not be too readily assumed that the metallurgical industries deserve to have the finger of scorn pointed at them because they have not instantly adopted so great a scientific improvement.

18 These remarks are intended as a defense of the attitude of the metallurgist and as a warning against hasty and ill-considered judgment on this subject.

C. G. ATWATER In discussing Mr. Junge's paper, it is but fair to warmly commend the broad position that it takes, and to compliment the author on the thoroughness and extent of the technical information that it displays. This paper, together with Mr. Junge's other contributions to the literature of the gas engine, form a notable addition to the published information on the subject. The assumption of the scientific point of view, and the discussion of subjects from this side seems to be a method of study that the American engineer and the American manufacturer are by no means overprone to adopt. All the more, therefore, we should welcome a paper of this character, particularly when on so timely and vital a subject as the gas engine.

2 Any criticisms that I have to offer bear on matters of detail, and are of small value when compared to the paper as a whole.

3 In paragraph 22, Mr. Junge appositely sums up the proper methods of appraising waste gases as corresponding to a certain weight of coal, a certain weight of steam, or according to "some other standard, depending upon local conditions." As regards the waste gases from the beehive coke ovens of the Connellsville and other regions, it is hard to say what the local standard is, but it seems certain that it could not be replaced by a lower one, as they are now worth less than nothing.

4 In paragraph 32, he says that it "cannot be said that the gasification of coking coals is an accomplished fact." If this refers to the use of the suction producer, it is doubtless true, as far as my information goes, but if it is to include the pressure type of producer as well it seems somewhat too sweeping. Bituminous coking coals are not favored by any means by those who wish to operate gas engines, but it is hardly fair to say that it cannot be done. Some of the tests made at the St. Louis Station by the United States Geological survey were presumably on coking coals, notably those from Alabama and West Virginia. It is not so stated, but as far as can be judged, they seem to have been of that nature. Also in the later lines of this paragraph, mention is made of the method of fixing tarry vapors in gas from such coals by drawing through an auxiliary fuel bed. If this method is successful, it removes one great objection to the use of bituminous coals in the producer by eliminating the cleaning plant. The numerous gas producers in operation in the Pittsburg and other districts where a coking coal is the cheapest, are evidence that such a coal can be worked, though I am not aware that the gas is used for gas engines.

5 In note to paragraph 47, it is stated that the gain which can be effected from the sensible heat of the gases in steam boilers, from their sensible and inherent heat, or from their combustion in gas engines is the same for the beehive coke oven, the by-product oven, or the regenerative oven. The point of distinction between the by-product and the regenerative oven is not clear, nor does it seem possible that as much available heat can in practice be recovered from a beehive oven, the waste gases from which are led through a steam boiler, as can be recovered from a regenerative by-product coke oven, wasting only the heat of the exit gases, and from the regenerators delivering a maximum of heat in the form of surplus gas.

6 Exact data for comparison are hard to secure, as tests of beehive ovens in connection with boilers are few, and do not show even fairly favorable results. I would like to know, therefore, the data on which this conclusion is based.

7 Further, Mr. Junge states that in ovens of the latest Otto type, up to 4940 cubic feet of gas of 448 B.t.u. is obtained as surplus; this figure has been much exceeded by ovens in this country, which have delivered 30 per cent or 40 per cent more heat units than this, the surplus approaching or equaling the above figure in quantity, and far exceeding it in calorific value.

MR. A. J. WOOD Attention may be called to the following errors:

Page 192, 7th line reads:

$$\eta_t = \frac{Q_1 - Q_2}{Q_1} = \frac{T_c - T_d}{T_c} = \frac{T_b T_a}{T_c}$$

should read:

$$\eta_t = \frac{Q_1 - Q_2}{Q_1} = \frac{T_c - T_d}{T_c} = \frac{T_b - T_a}{T_b}$$

Page 192, 5th line of paragraph 88 reads:

$$v_a = 22.72 \text{ mm. } (.895'')$$

should read:

$$v_2 = 22.72 \text{ mm. } (.895'')$$

Page 192, 3d line from bottom reads:

(187.8° F.)

should read:

(1878° F.)

Page 193, last line of paragraph 89, I obtain

$$\eta_t = \frac{T_b - T_a}{T_b} = 61 \text{ per cent}$$

2 It may be noted that the efficiency for the ideal Otto cycle at full load is 51.4 per cent and for the constant pressure cycle 55.6 per cent. One might, at first, be led to infer from this that, in general, the Diesel engine cycle gives a greater efficiency than the Otto. It should be noted, however, that the compression volume was different in the two cycles; the author has taken the same maximum pressures in the cases cited. Had the Otto compressed to the same *volume* as the Diesel, the efficiency in the former cycle would have been:

$$\eta_t = 1 - \left(\frac{v_2}{v_1}\right)^{n-1} = 1 - \left(\frac{22.72}{222.72}\right)^{.41} = 59.2 \text{ per cent,}$$

thus giving 3.6 per cent in favor of the Otto instead of 4.2 per cent in favor of the Diesel.

3 The efficiency of the Diesel cycle may be expressed in the following form, which will serve to show at a glance its difference from the Otto efficiency:

$$\eta_t = \frac{Q_1 - Q_2}{Q_1} = 1 - \left(\frac{v_2}{v_1}\right)^{n-1} \cdot \frac{1}{n}\left(\frac{R^n - 1}{R - 1}\right); \text{ where } R = \frac{v_3}{v_2};$$

from which it is evident that the efficiency will increase as R (or the load) decreases. For example, suppose the load drops off one-half, the influx of heat being $\frac{Q_1}{2}$, then R will decrease 50 per cent, but the efficiency will increase. This is exactly what the author finds and brings out in paragraphs 88 and 89.

4 Again, turning to the Otto; with quantity regulation, the author shows that the efficiency decreases with decrease of load; examine the equation:

$$\eta_t = 1 - \left(\frac{v_2}{v_1}\right)^{n-1}, \text{ with quantity regulation,}$$

as v_1 decreases (the compression volume v_2 remaining the same) the efficiency decreases; but with *quality* regulation, v_2 and v_1 remain the same and the efficiency of the whole cycle is unchanged—a striking contrast to what is found in the Diesel.

5 Do not these observations point favorably to the Otto theoretical cycle in preference to the Diesel on the basis of a comparison for full load and *quality* regulation? One would not hold, of course, that the Otto engine can practically compress to the amount of the Diesel and then explode the charge at constant volume. I am referring here to the theoretical cycles only.

MR. GEO. J. RATHBUN The following remarks apply only to engines governed by varying the quantity of mixture admitted to the cylinders during a cycle, and are intended to suggest, rather than prove, certain possibilities that, according to the writer's personal experience, seem to be worthy of consideration.

2 Overload capacity in a gas engine is obviously a necessity. Engines of this type are rapidly taking the place of steam engines for all classes of service, and they are consequently called upon to handle variable loads and large overloads of short duration. This is particularly true in electrical transmission, where a large variable motor load is obtained. In operating on producer gas, there is liable to be a variation in the quality of the gas. If the engine has no overload capacity the installation will not be satisfactory. As long as the highest economy is obtained at maximum load, manufacturers and users will be disposed to rate the engines as near the limit as possible. It is reasonable to suppose that builders would be glad to rate their engines to carry a 35 per cent overload, if the economy at rating was practically the same as at maximum overload.

3 Mr. Junge in paragraph 13 deplores the lack of overload capacity in gas engines, stating that the difficulty cannot be overcome, being inherent in the cycle. The writer believes this statement to be unwarranted, and will try and offer a few reasons to substantiate his conviction.

4 It is obvious from a consideration of the Otto cycle, that increased compression means increased economy. This cycle, however, is never obtained in an operating engine. We must consequently look to the engine itself if we are to consider its limitations and possibilities.

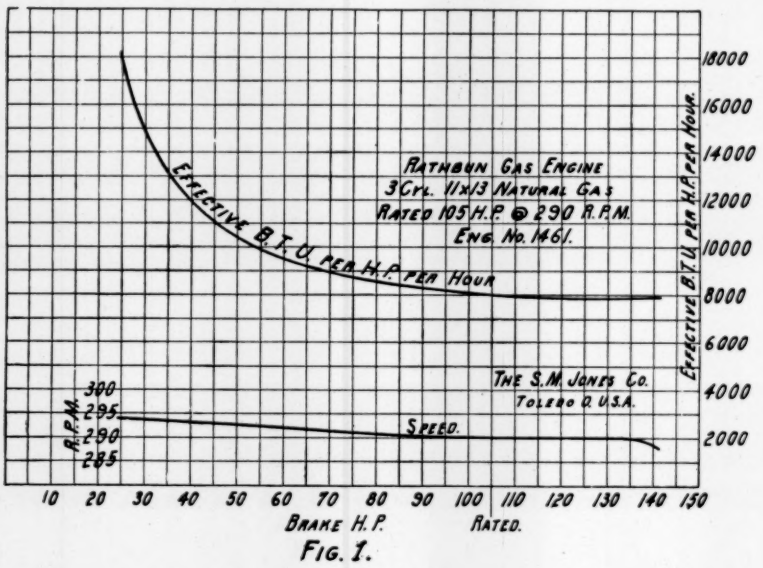

FIG. 1.

RATHBUN GAS ENGINE, 3 CYLINDER 11 x 13, NATURAL GAS. RATED 105 H.P. AT 290 R. P. M. ENGINE NO. 1461

5 Compression does not appear to be the most important factor in economy when it is remembered that there are various engines on the market today, all having the same compression pressure, but delivering a brake horse-power hour on from 8000 to 16,000 effective B.t.u., respectively.

6 Gas engine builders are familiar with the fact that each particular engine has its limit of economical compression pressure. If carried beyond a certain point there is no increase in economy or mean effective pressure. The effect of the increased initial temperature is offset by the increased rate of radiation to the water jacket.

7 The inference seems to be obvious: design an engine that will give a brake horse-power hour on 8000 B. t. u.; proportion the clearance so that the maximum indicated thermal efficiency is obtained at 26 per cent below the maximum horse-power. This will give the engine an overload capacity to 35 per cent with practically uniform efficiency.

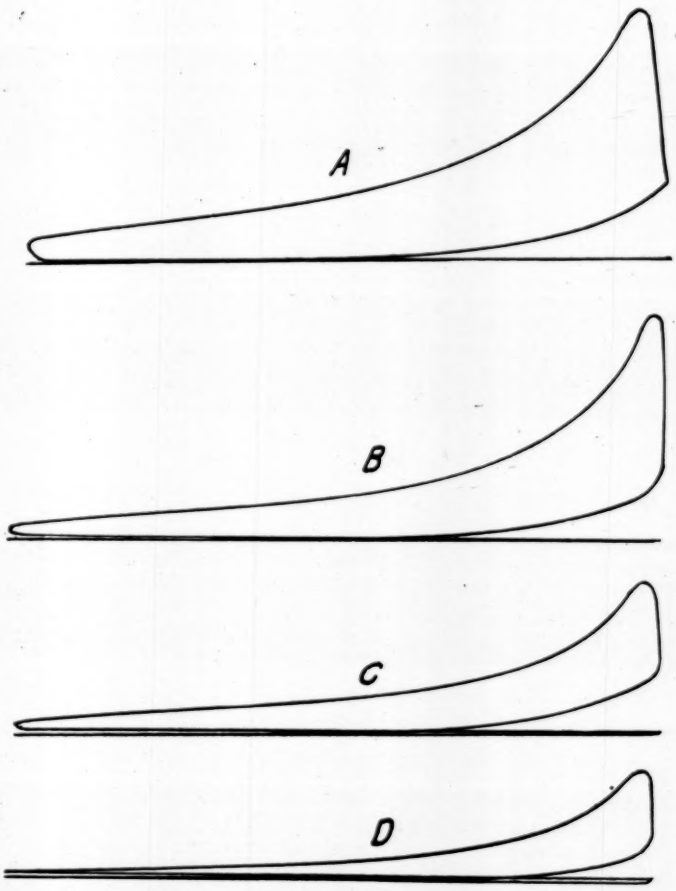

FIG. 2 CARDS TAKEN FROM ENGINE AT OVERLOAD, RATED LOAD 50 PER CENT AND 25 PER CENT

8 This proposition undoubtedly offers difficulties. particularly on some designs, and like all ideal conditions can only be approached in practice. The writer is of the opinion that investigations along this line will be barren of results, unless the engine is equipped with automatically controlled ignition. As a matter of fact, controlled

ignition will probably have more influence on developments in the efficiency of high efficiency engines than any other apparent factor.

9 Fig. 1 shows gas consumption curve on a 105 horse power vertical multiple cylinder engine, equipped with variable ignition controlled by the governor. Fig. 2 shows typical cards taken from this engine at overload, rated load 50 per cent load, and 25 per cent load. These diagrams are not offered as representing an ultimate test of the engine in question. The writer does not claim that this engine has been developed to the limit along the lines discussed. This test is offered to show relative and comparative results. It seems to indicate that there is some hope of increasing efficiencies below maximum loads, in spite of a defective cycle.

10 The writer is firmly convinced that this subject is worthy of careful consideration and regrets, for the time being, that he is a builder, not an author, and only has an insignificant amount of data to offer.

11 Gas engine efficiencies below maximum loads will eventually be greatly improved. For small units the means are probably at hand to produce the result commercially. In the case of larger units, it may be necessary to wait until structural material of higher tensile strength can be produced at a much lower cost than obtains at present.

THE FLOW OF FLUIDS IN A VENTURI TUBE

By Edgar Park Coleman, Published in November Proceedings

Mr. Sanford A. Moss I would like to add to Mr. Coleman's remarks in praise of the use of a Venturi meter for measurement of gases. I have been using one for some time for the measurement of compressed air and have found it satisfactory in all respects. I have made calibrations of the instrument, similar to those made by Mr. Coleman, by comparison with discharge through a calibrated orifice, and have obtained practically the same results as those obtained by Mr. Coleman. That is to say, within errors of observation, the flow as measured by the Venturi meter agrees with the flow as measured by the orifice.

2 There is only one point of doubt in the whole matter and that is as regards the exact coefficient of discharge of the nozzle forming the initial portion of the Venturi meter. This coefficient possibly varies from .94 to .99. Of course, for usual commercial purposes, this difference is not significant and the coefficient may be guessed as .96 or .97. The Venturi meter will then be a perfectly satisfactory com-

mercial instrument on which no further research or experiments are necessary. However, for more accurate work, it would be desirable to obtain more exact values of the coefficient under various circumstances. If such exact values were obtained, the Venturi meter would be an instrument of precision for both liquids and gases.

3 A set of mathematical formulæ for use of Venturi meters, equivalent to those of Mr. Coleman, but differing somewhat in form, is given in the "American Machinist," of September 20 and 27. The formulæ are there somewhat simplified by the fact that for the usual case the entrance velocity is practically negligible, and by use of an approximation first suggested by Boussinesq the results obtained are almost identical with those of the formidable exact formulæ.

4 I would like to inquire as to what coefficient of discharge Mr. Coleman used in reducing his experimental measurements of quantity by Venturi meter so as so compare with the measurements by other methods.

MR. CLEMENS HERSCHEL Venturi's experiments, published in 1797 were made with *expanding* ajutages only; not with compound tubes, such as I invented to be used as a water meter, in 1887, and then named the Venturi Meter.

2 There is a tendency now to call such a tube a Venturi tube, and perhaps this serves me right for not having named the combination the Herschel Meter, when the bantling was in my hands to be named. But this is a small matter. See "Cassier's Magazine," March, 1899, for a history of the invention.

3 From the beginning it has been intended to use the instrument for metering any and all gases, no less than water; using the term gas in the general sense, which would include steam, compressed air, etc., but the valuable experiments and computations of the author of the paper are the first published on that class of work. Before the Boer war, negotiations were in progress to use the meter to measure the compressed air generated by one central station as it was distributed to several mining companies; but the negotiations were broken up by that war, and its only use for measuring gases, that I know of, is by the United Water Improvement Co. of Philadelphia, which practices the purification of water by the Vosmaer Ozone Process, by metering the ozonized air on its way to the standpipe which contains the water to be purified.

4 The author of the paper is disposed to rate the Venturi Meter of gases by the use of Pitot tubes, and in the experiments here reviewed,

the Pitot tube was used in the throat of a Venturi meter tube, apparently with the downstream cone of the meter first removed.

5 The question arises whether the discharge of the gas metered and the record of the pressure chamber of the Venturi meter would be exactly alike, when this downstream cone was on or off. But should a minute error lurk here, it seems to me that it would be more exact to test such a meter by volumetric measurement, by means of drawing from or into gas holders, and then test any Pitot tube system of metering the flow in pipes which may be selected, either by the same gas holders, or by the rated Venturi meter; provided any laborious and expensive use (in time, salaries, and money) of Pitot tubes would ever be wanted, after the Venturi meter for gases was once as well established as it is for metering water. It must always be remembered that rating any form of current or velocity meter does not establish the degree of accuracy of a form of volumetric metering, in which the current meter referred to, is to be or has been used. These two kinds of tests are always, or should always, be considered as quite distinct; even when perfect work, free from personal equation or error may be assumed on the part of any one, or successive, individual manipulators of the current meter in question.

6 A certificate of accuracy of any method of metering must depend, at some point in its genesis, on a strictly volumetric measurement; and following this, on a comparison between the computation made, and the absolute volume of the quantity metered. Anything less than that will leave the user uncertain how closely theory followed by computation have come to represent the operation of the natural laws which produced the discharge volume which has been passing. Once rate the Venturi meter by gas holder test to meter gases, and it will replace, or can be used thereafter to test a Pitot tube or any other velocity meter method of metering such gases.

VENTILATION OF THE BOSTON SUBWAY

By Mr. H. A. Carson, Published in October Proceedings

Mr. W. Clifford Assuming the number of passengers at Park Street Station to be 90,000,000 per year, equal to 246,570 per day of 24 hours, or an average of 10,000 per hour, or say 30,000 during the busiest hour of the day, and assuming 100 cubic feet of air per passenger per minute diffused through the station, a ventilation of 50,000 feet per minute would be required at this point.

2 If the efficiency of ventilation alone is to be considered, placing an exhaust fan midway between two stations is a good arrangement,

provided the volume produced is sufficiently large to maintain a velocity of current that will carry away the impalpable dust, or even the larger particles stirred up by the moving trains, or ground off the tires of the wheels and the contact shoes of the third rail. A means of automatically increasing the speed of the fan to maintain the fixed normal volume (when increased resistance, through the piston action of meeting trains tends to diminish it), should also be provided.

3 This piston action of moving trains was very noticeable during the limited experiments made by the writer with the fan placed at the top of Hoosac Mountain shaft to ventilate the tunnel. It was found that the water gage, or resistance, varied from .36 to .8 inches with 394,000 cubic feet of air passing at the former gage.

Size of fan, 16 feet diameter, 8 feet wide.
Revolutions per minute, 110.
Total horse power indicated by meters, 127.
Horse power required to drive jack-shaft when fan was cut out, 96.
Power delivered to fan pulley, 31.
Horse power in the air, 22.6
Mechanical efficiency, 73 per cent.

4 These figures do not bear directly on the subject under discussion, but it was thought they might be interesting.

5 This short Boston subway could easily be ventilated by one installation giving a high standard of mechanical efficiency, say 80 per cent with an electric drive, and in case of a long subway like New York, one installation could be used to cover ten miles of tunnel to a very great advantage. There can be no objection to high speed of ventilating current where there is already rapid movement of trains.

6 In ventilating mines, the writer frequently recommends their laying out in such a way that the whole ventilating power of the fan can be directed through one split or division of a mine at once, when desired. This often means a current velocity of 60 miles an hour. One hour's application of this hurricane ventilation removes all dangerous dust and more effectually prevents explosions than weeks of expensive water sprinkling. Apart from the nature of the danger, the same principle holds good with a ventilating current of a tunnel.

MR. FRANCIS FOX As the Boston subway is worked electrically, the question of ventilation is greatly simplified, as compared with tunnels in which the products of combustion from steam locomotives have also to be considered.

2 Assuming 30 cubic feet per minute per person as the volume of air required to maintain purity, this being the standard we adopt, I arrive at the following results, which are necessarily only approximate, as I have not all the necessary data upon which to base the calculations.

3 I observe that the traffic in the first 12 months was 50,000,000 passengers, and these have increased in number 60 per cent or 30,000,000, making a total for the year of 80,000,000. Assuming the traffic on Sundays to be one half of that on ordinary week days, we take 340 full days for the year; this gives a daily traffic of 235,294. Assuming that one fourth of this represents the crush hour traffic of one hour duration under the most congested conditions, we obtain 59,000, as the figure representing the maximum number of passengers passing through in one hour.

4 I have no data as to the average time each passenger is in the subway, but I assume it to be eight minutes; this gives 7866 minute-passengers to be provided with 30 cubic feet of air, or a total volume of air required of 235,980 cubic feet per minute.

5 From the paper, I gather that the volume of air being exhausted from the tunnel, and which is therefore replaced by fresh air from outside is 292,000, thus showing that the purity of the air is all that can be desired.

6 In London we have certain electrical railways which are insufficiently ventilated, whilst on the other hand some are over ventilated, insomuch that objectionable draughts are produced, which act as deterrents to some intending passengers.

7 A happy medium between over and under ventilation is what is required, combined with careful observation of the force and duration of the wind outside, and in the Boston subway this can evidently be attained.

8 The ventilating duct in the crown of the tunnel is a satisfactory arrangement in the case of electrical railways where soot has not to be contended with, and as it has a sectional area of 48 square feet for a volume of 45,000 cubic feet per minute, the velocity is not excessive.

9 The author very properly points out that the olfactory organs and the lungs are much more delicate tests as to the presence in the air of certain impurities, than any chemical analysis, and I also note with pleasure his remark that much more attention is required as to the ventilation of the actual cars themselves. I called attention to this question in the paper I communicated to the St. Louis Exhibition Conference of Engineers in 1904. In fact, were the

cars and carriages thrown open to the air of properly ventilated tunnels the public would be great gainers.

10 We engineers are constantly striving to attain fresh air, but the traveling public shut themselves up in vitiated air, often of appalling character, by keeping the doors and windows closed.

11 As regards the cooling of the air in tunnels, we have found the greatest advantage in the adoption of fine spraying of water in the Simplon Tunnel. By this means the temperature of the air can easily be lowered by 20 to 30 degrees Fahr., or even more.

12 In conclusion, I am glad to find that the system of ventilation of the Mersey Tunnel, which was carried out in 1880–1886 (and was then described as drawing vitiated air from the tunnel at a point midway between the stations, and which has stood the test of 20 years of experience), has been applied to the Boston subway with so much skill and so much deserved success.

MR. WALTER B. SNOW The original paper and Professor Woodbridge's discussion refer to an air change once in ten minutes and to a flow of one linear foot per second from each station toward each center of discharge. The change of air is sufficient to meet all ordinary conditions, but such a low rate of flow (which is a measure of a vacuum produced) would leave any ventilating system practically powerless to overcome the effect of ordinary atmospheric changes. A difference of only .01 inch of water is sufficient to produce a velocity about six times greater than that planned for the subway. What must be the result when large open portals and numerous entrances and exits, to say nothing of moving trains, afford ample opportunity for the creation of pressure differences much greater than .01 inch. Under these conditions the fan becomes merely local in its effect. It is practically powerless to control the direction of currents at such distances as exist in the subway. In a word, so long as the subway connects through large openings with the outer atmosphere, it is impossible for the fans of the capacity here installed to properly control the flow of air. The trouble in the case of this installation is not with the fan, but with its size. The problem is one of volume and velocity, which must be sufficient to insure the maintenance of a pressure difference which cannot be overcome by atmospheric conditions.

TEST OF A ROTARY PUMP

By Mr. W. B. Gregory, Published in November Proceedings, Supplement

R. C. Carpenter The high efficiency which is shown by the rotary pump, the test of which is given in Professor Gregory's paper, is remarkable. It is so high as to raise a doubt in the minds of those acquainted with this kind of work as to the correctness of the results. In accordance with the paper the total losses existing between the engine piston and the water delivered is only 16.7 per cent. The friction and other losses in an engine of the class shown, namely, a horizontal tandem-compound Corliss engine, is not likely to be under 10 per cent. The friction losses in the pump driving gears can hardly be less than 2 per cent unless they are of unusually perfect construction. Calculation of this kind would indicate if the results of the tests are correct, that the efficiency of the pump must have approximated 95 per cent, an amount which in my opinion is practically impossible to attain with the construction shown, since the pump is subjected to friction and hydraulic losses as well as leakage.

2 I am not able to point out the probable source of error in the test, but I would suggest that it might lay in the use of the Pitot tube, an instrument for measuring the discharge of water.

3 In connection with the test of the Ontario Power Plant at Niagara Falls in 1905, I made a great many experiments respecting the measurement of water with Pitot tubes of different forms and in this work I was assisted by able and experienced hydraulic engineers. As a result of the investigation I found that Pitot tubes were accurate and reliable when used under proper conditions for the measurement of water, but I also found that in order to get accurate results it was necessary to use them under favorable conditions. I found that the constant for the Pitot tube changed very greatly with different conditions of use, and that in order to get reliable results it was necessary to calibrate it under the identical condition of use. I found, for instance, that an extreme variation of 4 per cent would be shown by calibrating from the traverse of a pipe as compared with a calibration obtained by moving the tube at a known velocity in still water.

4 The result sheet of the paper shows that the Pitot tube readings gave discharge results which agreed very closely with that calculated from the displacement of the pump. This also is one reason for the expression of my opinion that the discharge results and consequently the efficiencies shown are too high.

MR. A. M. LOCKETT Professor Gregory's paper is very interesting to me for the reason that it confirms a belief which I have always entertained that a rotary pump of the type described is a very efficient machine for handling large volumes of water under low heads, but I have always believed that the practical difficulties in the way of the continuous operation of such pumps under the average working conditions called for in irrigating the Southern rice fields render it extremely doubtful whether, in spite of the exceptional efficiency, the machine should be looked upon as a good commercial investment.

2 I am not sure that the points upon which I wish to touch properly come under a discussion of Professor Gregory's paper, because this paper is an account of a scientific test, the accuracy of which is not questioned, but upon the grounds that a paper of this character when read by possible purchasers will undoubtedly carry great weight, I think that it would be to the interests of the public if Professor Gregory would answer the questions which I propose to ask, or prepare another paper dealing with this problem from the standpoint of a commercial investment. I would like to ask Professor Gregory whether he has made any investigation along these lines and if after such investigation he has come to the conclusion that the Rotary Pump is a better commercial proposition than the Centrifugal for irrigating the rice lands of the Southwest? It occurs to me that in the selection of the proper type of machine for any given work, the efficiency is not the only consideration; first cost, liability to breakage, the cost of renewing parts, the ability to force beyond rated capacity, and such like considerations are in most cases equally as important, and in the irrigation of land are of first importance. I would submit for this consideration the following points:

a On the basis of 83 per cent efficiency for the Rotary and 70 per cent for the Centrifugal, will the additional first cost be justified as a commercial investment?

3 Taking Professor Gregory's estimate of fuel cost for the Neches plant at $4.12 per hour with the 83 per cent plant will mean a saving of about 77 cents per hour or $18.48 per day of 24 hours. Taking ninety full days as the average pumpage in the Louisiana and Texas Irrigation Districts means a yearly saving in fuel of $1663. Money in that part of the country cannot be had for less than 6 per cent and allowing 7 per cent for depreciation, we find that a saving of $1663 would justify an additional first cost of $12,791. What is the additional cost of four of these machines over centrifugal pumps of the same capacity? My impression is that this difference will be more than the amount named.

b Can these pumps be depended upon to deliver their rated capacities without danger of breakage?

4 In Mr. Wilkin's paper upon this same subject in Volume 24 of the Society Proceedings, he uses the following language:

"An interesting experience was had with two pumps, each to have a capacity of 25,000 gallons per minute lifted 31 feet coupled direct to a Corliss engine, running at about 67 revolutions per minute. We designed them with two air chambers on the discharge and two on the suction side of the pumps, placing them as near as possible to the impellers, the air chambers having connections to the pumps seven inches in diameter. When we began to operate the pumps we found that they would run smoothly up to 50 revolutions, at which speed a powerful water hammer occurred. We attached an indicator to the discharge side of the pump 18 feet below the upper water level and found that the pressure there varied from 5 or 6 pounds vacuum to 30 or 40 pounds pressure. The action on the suction side was similar, except that the vacuum was 12 pounds and the pressure rose slightly above atmosphere."

5 Evidently, there was something serious going on in that pump. You will note that the pump was working under an actual lift of 31 feet. On the assumption that the maximum pressure on the discharge of 40 pounds occurred simultaneously with the maximum vacuum on the suction of 12 pounds we have a momentary head of 120 feet or an overload of more than 300 per cent, not taking into consideration the difference in elevation of the two gages.

6 If these strains existed in the pumps referred to with four air chambers, it would be interesting to know what proportion of such dangerous shocks have been removed by the modified air chambers in use on the pumps under discussion. I would ask Professor Gregory if he took any indicator cards from the pumps.

7 I would also call attention to the fact that in Mr. Wilkin's paper, he refers to the plant tested by Professor Gregory as consisting of four units each of 35,000 gallons a minute capacity or a total of 140,000 gallons, whereas the capacity as shown by Professor Gregory's log is 130,700.

c Can these pumps in an emergency due to breakdown of other units be safely forced above their rated capacity as can be done with a centrifugal pump?

8 Manifestly in a pump handling the immense mass of water contained in the pump itself and the suction and discharge pipes connected thereto, in which the water is propelled in a series of impulses, the inertia of this water becomes a very formidable proposition and

one naturally assumes that even though the air chamber is ever so large, there is a point beyond which the machine can not be safely operated. By reason of the high cost of these machines, I suspect that the manufacturer is almost compelled to rate his machines at that maximum safe speed, and if such is the case, it occurs to me that the machine for practical use does not compare favorably with the centrifugal, where the limit to the speed is the limit to the engine speed and power.

d Is this pump liable to breakage by reason of foreign substances entering through the suction pipe? What will happen if a nut or bolt should find its way between the two impellers?

9 I have had to do with a number of irrigating plants and I know that in nearly every plant, sooner or later, the pump will be called upon to handle many things beside water.

What would be the effect on this pump if the water carried large quantities of sand? I happen to know of one irrigating plant where so much sand has passed through the pump that the canal, 150 feet wide, is practically filled for half a mile, and the centrifugal pump is showing high efficiency; this after four years of such service.

10 My object in calling attention to these points is that, by reason of Professor Gregory's great reputation as an expert in this class of work, his report will, no doubt, be taken as conclusive argument in favor of the Rotary Pump as an irrigating machine, and I have very good reason to believe that in spite of its superior efficiency under test the Rotary Pump is not so good a commercial proposition as a high efficiency Centrifugal. There are Centrifugal plants in the Southwest showing as high as 70 per cent combined efficiency, and of a total of nine large pumps installed by the writer during the past six years not one has had a breakdown of any kind nor involved any expense whatever in the way of repairs to the pumps proper.

IMPROVED TRANSMISSION DYNAMOMETER

By Prof. W. F. Durand, Published in November Proceedings

Prof. J. J. Flather I have been greatly interested in reading Professor Durand's paper on "An Improved Transmission Dynamometer" and am pleased to note that the machine presented offers an excellent means of accurately transmitting power without the usual expensive and frequently cumbersome apparatus often found in our laboratories.

2 This machine, as the author states, is a modification of the Tatham transmission dynamometer, described in the "Journal of the Franklin Institute," December, 1882, and November, 1885. This type of dynamometer is free from the objection so common to many other forms; namely, the effect of centrifugal force under high speeds. The capacity of the present machine is much greater than one would expect and its compact and light form renders it available for a variety of work where a heavier machine would be very troublesome.

3 The introduction of ball bearings in the main shafts may cause trouble. With light loads and high speeds they may be expected to give very satisfactory results, but the writer would prefer roller bearings for this work. The convenience of an overhanging pulley for receiving and delivering the power is probably sufficient to warrant its use, although this arrangement possesses some disadvantages which might give erroneous results under certain conditions. However, any additional outside bearings would materially increase the size and weight of the apparatus and thus make it less available for general work. The use of the Emery flexible plate instead of pins or knife edges is to be commended. While a hardened steel knife edge in the present case would probably not cause any appreciable error, the use of the plate with limiting stops produces no friction at all and is to be preferred. The simplicity of design and ease of construction are features which will appeal to the engineer outside of the laboratory, for a very satisfactory machine of this type can readily be made almost anywhere at small expense and in a short time. This machine is certainly a great improvement on the ordinary belt transmission dynamometer.

SAW-TOOTH ROOFS FOR FACTORIES

By Mr. Knight C. Richmond, Published in November Proceedings

Mr. H. V. Haight I wish to comment on Mr. Richmond's paper simply to draw attention to some advantages in making the saw-teeth with window faces vertical. We are using this style on a foundry 100 feet wide which has a central bay 50 feet wide and two side bays 25 feet wide. Wishing to have particularly good light in the central bay, we have made the roof of this part on the saw-tooth style, but with vertical window faces. We made these faces vertical for two reasons, the first being that it permits the use of ordinary windows instead of the expensive skylights. The other reason was that we wished to provide for double windows, as is usual in this climate. The question of double windows had considerable weight with us,

as they make a reduction in the size of the plant required to heat the building, and, of course, in the running expenses of heating also. The windows in the saw-teeth being the highest ones in the building, are the ones which it is most necessary should have double sashes. When we were considering the inclined window faces we referred the double window question to several manufacturers of skylights, but none of them offered any solution.

2 Another form of construction which was offered to us consisted of cross monitors on top of the main bay, these monitors having windows all round. It appeared to us that this construction would hardly give as good lighting as the vertical face saw-teeth, as the saw-tooth construction seems to be better suited to reflecting the light from the roof through the windows and from the ceiling down to the floor.

3 The vertical face saw-tooth also adapts itself well to the steel construction, as instead of resting the whole saw-tooth construction on carrying-girders, the vertical face of the saw-tooth is made a light truss, which takes the place of the girder.

4 The window sills of the saw-teeth windows are about 14 feet above the highest point of the valley to obviate any trouble from snow. The building has interior drainage throughout, as we have had considerable trouble with the exterior drainage of the old shops, due to ice on the jets.

5 When the saw-tooth construction is used for machine shops or foundries, it does not appear essential to face the saw-teeth north. The most common construction for such shops is the monitor style, and there seems little objection in that case to light from the east, west, or south. Some go so far in the endeavor to face the saw-teeth windows of a machine shop due north as to run the teeth lengthwise or even diagonally of the shop, which appears absurd. We are facing the saw-teeth east.

MR. J. R. FORDYCE The preliminary state of cotton manufacture so long in a primitive state as compared to the final or mill end, has at last started on an awakening.

2 The saw-tooth roof, which as a means of lighting weave sheds has long been in use, is now applied to cotton compress sheds. Owing to the great bulk of the cotton bales and the fact that the crop is nearly all rushed into the compresses during October and November, the sheds are necessarily very large, and as they are unused during a long period of the year, they have to be cheaply constructed.

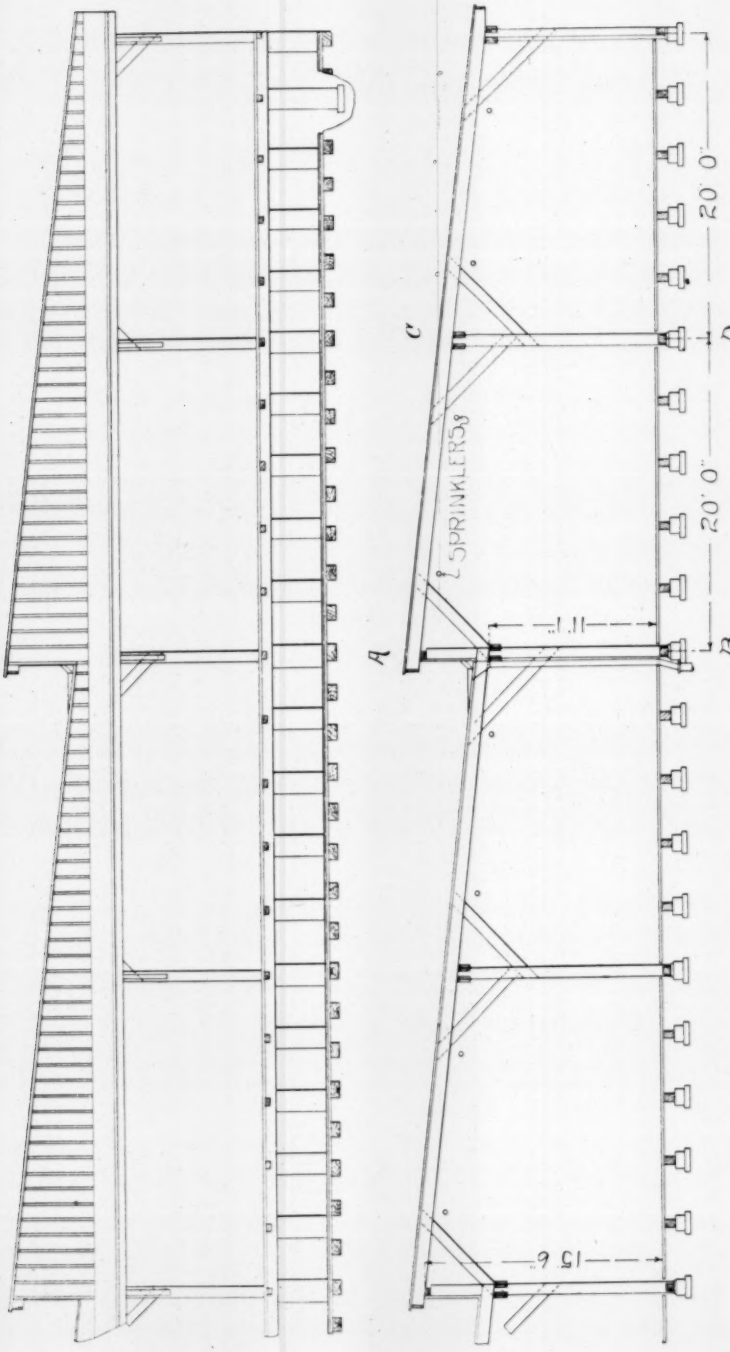

FIG. 1 SAW-TOOTH ROOFS USED IN COTTON COMPRESS SHEDS

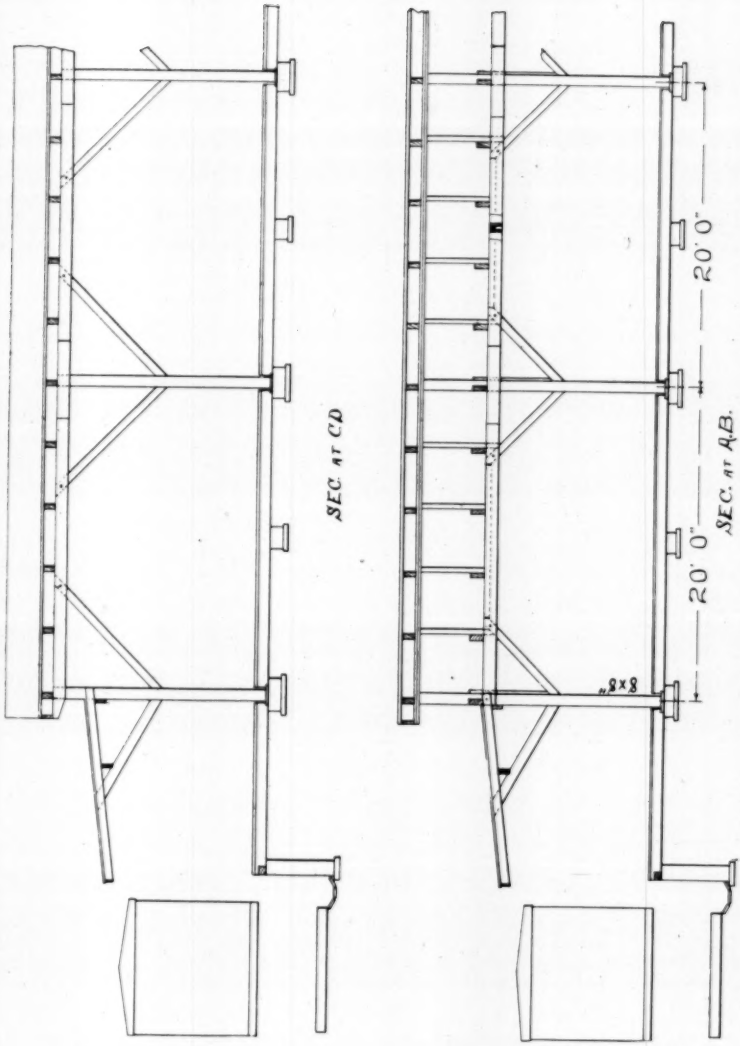

FIG. 2 SECTION AT A B AND C D SAW-TOOTH ROOFS USED IN COTTON COMPRESS SHEDS

3 The bales are brought into the sheds from the country gins on wagons and cars, and are then weighed, sampled, and marked. This takes a great deal of room and a good light is needed. As an enormous number of bales must be handled in so short a time, it is not economical to pile the bales on one another. Therefore, the sheds do not have to be very high.

4 To reduce the insurance rate on such large accumulations of cotton, automatic sprinklers are installed, and to be effective they must hang just over the bales. To meet all of these conditions, the sheds shown in the accompanying drawings have been designed and erected at various cotton centers in the South.

5 The construction is light, because we do not have heavy snow loads. The spacing of the posts are governed by the following conditions:

a Sizes of the cotton bales, which are grouped in lots of one hundred for sorting purposes;

b the available sizes of timber for rafter girders, etc.;

c the spacing of the rafters required by the spacing of the automatic sprinkler heads;

d the dead and live loads the roof has to carry.

6 The opening in the roof is vertical instead of inclining, on account of being simpler and cheaper in construction. The width of the opening is determined by the amount of light required and the pitch of the roof, which is covered preferably with tarred and graveled felt. The openings are turned south, instead of north, because we want the sunlight to dry out the cotton and warm up the negroes. When the roof is pitched toward the north it lasts longer in our climate than when it is pitched toward the south, owing to less direct rays of the sun, and, therefore, less evaporating effect on the oils in the felt. The sun also shines directly into the gutter and prevents the accumulation of ice and snow. The openings are covered with "wire fabric" to prevent the entrance of sparks, wind, and water, and because it is cheaper than glass.

7 The gutters are formed by wedges under the sheathing, giving a cross pitch of $\frac{1}{4}$ of an inch to the foot. No metal is used, but the felt is of double thickness along the gutter.

8 The conductor heads are spaced 40 feet apart, the down spouts, four inches in diameter, follow down the posts, and lead into tile drain pipes under the floor. These sheds seem to meet all of the conditions, and are satisfactory to all interests concerned.

MR. FRED S. HINDS Paragraph 4 would imply that Mr. Richmond considers there is little use of argument for saw-tooth roofs on heavy machine shop buildings which are relatively narrow, for instance, not over 100 to 125 feet wide. This, I would consider a fairly wide shop, and if more space could have been allotted for my photographs, I would have shown the DeLaval plant which has the saw-tooth skylights in the side wings, or on both sides of the crane shop. This method of lighting the side wings is very desirable to keep down an excessive height of the side wall required for side windows.

2 As machine shops are costing about 20 per cent more today than a few years ago, the height of buildings can be reduced at least 20 per cent by the introduction of saw-tooth skylights, thus bringing the cost of a new plant down to normal conditions.

3 Again, on referring to Paragraph 19, this paper reads: "* * * almost perfect for the most exacting requirements, and this is the pre-eminent advantage of saw-tooth lighting. By no means a small economy in the use of saw-tooth roofs is the saving in time during which artificial light is needed, as compared with side-lighted rooms in factories of usual proportions. The explanation seems to be primarily in the almost perfect light, and from the fact that a better class of help is attracted and retained for the very reason that the light and working conditions are better. In one case at least the advantage of the saw-tooth lighted building is distinctly measured by the lower piece price paid for weavers in the saw-tooth building as against the piece price paid weavers on the same class of work in the neighboring side-lighted building. The difference is stated to be 10 per cent.

4 In revising his paper, would it not be well to hold to paragraph 19 and eliminate paragraph 4?

5 In paragraph 5, Mr. Richmond makes a strong point in favor of a greater angle than that called for in my paper, and due credit should be given him for bringing out this feature, which is further illustrated by diagram, Fig. 1, herewith.

6 The secret of it is not the small projecting cornice, as I have considered it, and as will be noted in my paper, Fig. 3, but a stronger projection, as brought out in Mr. Richmond's paper, Fig. 3, which increases the angle from 19 to 30 degrees from the vertical. However, in all the other types, discussed by both papers on this subject, there is no instance where anyone has used this strong overhanging projection, or cornice, but they have used the 30 degrees and this surely admits rays of sunlight.

7 Those who have skylights of the type illustrated in my paper, Fig. 11 (these being finished in wood with no cornice), if the cornice were added (admitting that these saw-tooth skylights face the north), they would gain a greater amount of north light and the direct sun's rays would be entirely eliminated, as from the photograph I am led to believe that the angle is 30 degrees.

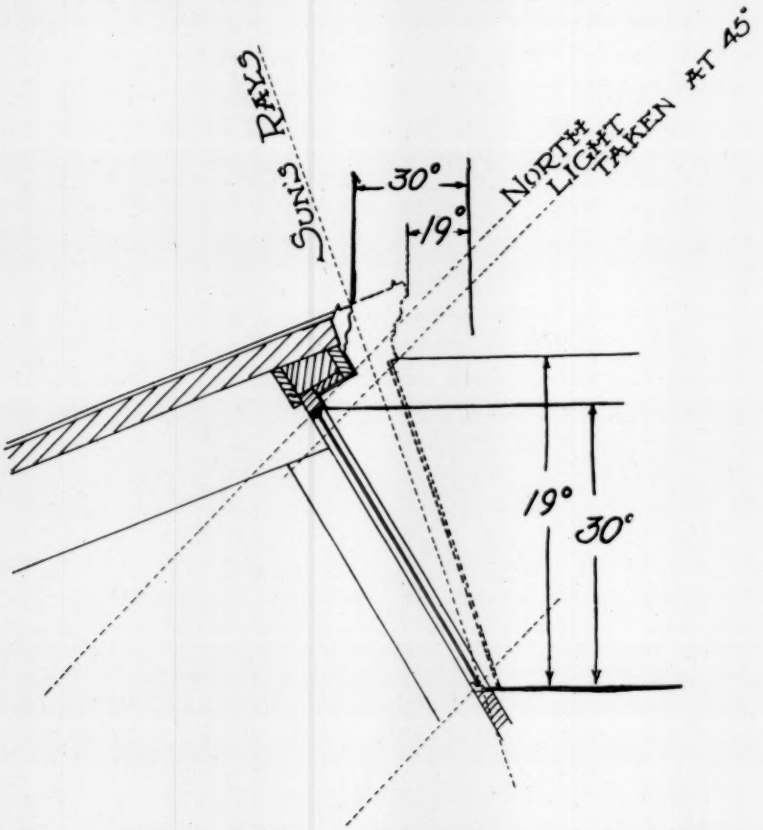

FIG. 1 DIAGRAM ILLUSTRATING APPLICATION OF OVERHANGING CORNICE

8 Therefore, the model for saw-tooth skylights is very easily compared by the other reference made in Mr. Richmond's paragraph, which describes it as a draftsman's 30 x 60 degree triangle, with the hypotenuse placed horizontal.

9 Paragraph 6 should be particularly noted for the reason that quite often in the designing of new factory plants, it is impossible to have the saw-tooth skylights face north and run either across the

building or lengthwise of the building, to conform to the lines of the property. There is an advantage in the 5 to 15 degrees which the buildings can face east of north and at the same time avoid direct sunlight before the whistle in the morning.

10 I would still further enlarge upon paragraph 9 and say that I consider gravel roofs or prepared gravel roofs not so well adapted to the long slant or back of skylights on account of the steep slopes, as the crushed slag in asphalt mentioned in this paragraph.

11 Paragraph 10 may have been Mr. Richmond's experience in mill work rather than that of factories or machine shops, for the reason that he makes a strong point that even 3 inch hard pine plank must be properly insulated to avoid condensation.

12 In my work of 27 years in planning industrial plants and textile mills, one of my first experiences was the use of $2\frac{1}{2}$ inch plank on the roof of one of the three mills erected for the Washington Mills Plant and on the Plymouth Cordage Company's one-story plant.

13 Condensation was discovered and the cause was finally laid to insufficient thickness of roof plank. At this time I began to use 3 inch plank which has eliminated the difficulty. As far as I know, on all the plants where I have used this thickness of plank there has been no further trouble.

14 I cannot see how there would be any trouble with double-glazed skylights in any of our factories or machine shops, unless they were over departments where the temperature would be about 80 degrees F. and a humidity of 70 to 80 degrees. From this it will be seen that the only place where insulation is required, if at all, is in textile plants.

15 As Mr. Richmond has reference more particularly to textile mills, it may be that there was insufficient or no ventilation provided, therefore paragraph 10—referring, as it does, entirely perhaps to textile mills—only bears partly upon the whole subject of factories and machine shops.

16 Paragraph 15. In reading this and examining the various types of saw-teeth in Figs. 1, 2, and 3, it is very evident that they are all of the English type. On a large part of these cuts he refers to the gutter between the skylights. Here is the weakest point in all these various designs of saw-tooth skylights, where, I contend, in preference to a gutter of any form, whether of sheet metal or cast iron, the flat roof space is the most practical.

17 I do not approve of the method of carrying off roof water by conductors in valleys or flat spaces between saw-tooth skylights, and avoid it in every way possible. The method of sloping the roof

toward the walls in order to carry away the water as quickly as possible from the back of these skylights is the surest method to avoid the troubles from water and snow collecting and freezing around the conductor outlets.

18 With saw-tooth skylights running lengthwise of the building, it is impossible to carry out this idea; therefore, there is all the more reason for having a wide space at the bottom of the saw-tooth, or what I designate as my Americanized system; namely, the flat roof space between each skylight, of 24 to 48 inches in width, according to the circumstances. This variation being in the slant of the back which is controlled by the height of the glass, should never be less than 24 inches wide.

19 Referring to the cost of saw-tooth skylights over that of the flat or plain roof, under paragraph 20, and in answer to the statement that this type of skylight increases the cost over the plain roof from 40 to 60 per cent, I would state that the increased advantage of a saw-tooth skylight is in bringing it down nearer to the work than would be possible with the usual high stories, and this I accomplish by reducing the height of the stories about three feet, thus saving three feet of brickwork over the whole area of the building and slightly saving the stock in the length of the columns. I believe this saving pays for the additional cost of my plain design of saw-tooth skylight.

20 I cannot agree with Mr. Richmond to bring in the increased cost of heating and sprinklers, for the reason that the great advantage of saw-tooth skylights should entirely eliminate these two items. In fact, when we consider that the saw-tooth form is simply raising one end of the roofing and setting that part of it on an angle, to admit of the space for the sash, and that it requires no more roofing space than it did when it was down on the level, how does it add a great many sprinkler heads?

21 Accompanying this discussion I wish to introduce a diagram, Fig. 1. The dotted lines of the skylight show the sash at an angle of 19 degrees, the lines in full of the skylights show it as 30 degrees, but with the addition of the overhanging cornice, with just enough projection to eliminate all direct rays of the sun.

22 On the basis of 48 inches of height of glass on which this diagram is laid out, there is a gain of 7 inches in width of light from the zenith and 3 inches more of north light, when based at an angle of 45 degrees, for the reason that the 48 inches of glass is tipped down nearer to a right angle with the angle of north light, making a gain of 3 inches more, thus securing practically 10 inches of stronger light.

23 It is only possible to throw light through a space of 48 inches but if it can be increased by 10 inches with a stronger light, gaining the advantage of the zenith light, there is no question but that this is an improved method over any other type.

SAW-TOOTH SKYLIGHT IN FACTORY ROOF CONSTRUCTION

By Mr. Fred S. Hinds, Published in October Proceedings

Mr. W. B. Snow An additional feature in the design of the roof of the B. F. Sturtevant Company's machine shop should be noted. The shop, which is of the gallery type, is 120 feet wide with a central craneway 40 feet wide. The transverse saw-tooth skylights are 60 feet long; that is, they overreach the gallery floors by 10 feet. Immediately beneath this overreach on either side runs a bench which, because of the excellent lighting, is very generally utilized for fitting and similar work. In fact, this is one of the most important features of this particular application of the saw-tooth. It is unfortunate that through the combination of short exposure for the photograph, a poor halftone and the dark-colored background, the lower portion of Fig. 8 suggests extremely poor lighting. From Fig. 9, which shows the other side of the crane girded, the true value of the lighting is evident.

2 No ventilators were provided for these skylights. A little calculation will at once show the relatively slight air movement created through such devices when the temperature difference between indoors and out is as slight as that which occurs in midsummer. Naturally the best ventilation results when least needed, namely, in midwinter. Much larger areas or positive-acting fans are necessary to secure a movement adequate for increasing the comfort on summer days.

3 Actual experience has shown no great discomfort existing in the gallery of this shop, as compared with that in the third floor of a parallel shop, which has a roof of ordinary mill construction without skylights.

4 There is evidently an error in Mr. Hind's statements made in paragraphs 38 and 39, which would indicate that the skylights shown in Fig. 9 have been changed. Such is not the case.

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